LATKE: A Framework for Constructing Identity-Binding PAKEs

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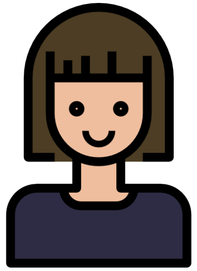
University of Maryland, Google

Michael Rosenberg, PhD(!)
University of Maryland

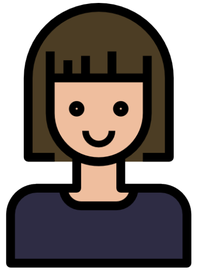
ia.cr/2023/324

What is a PAKE



What is a PAKE

Two parties use a password to establish a secure shared secret



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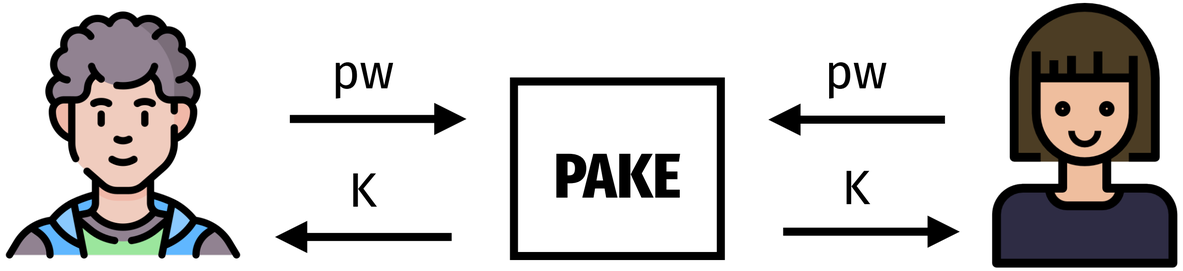

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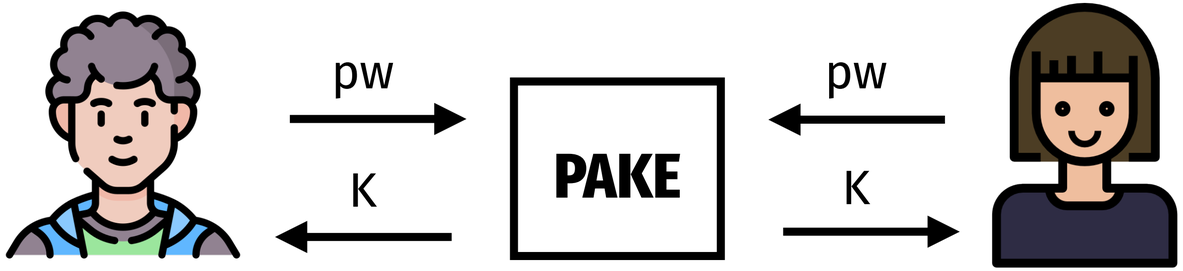

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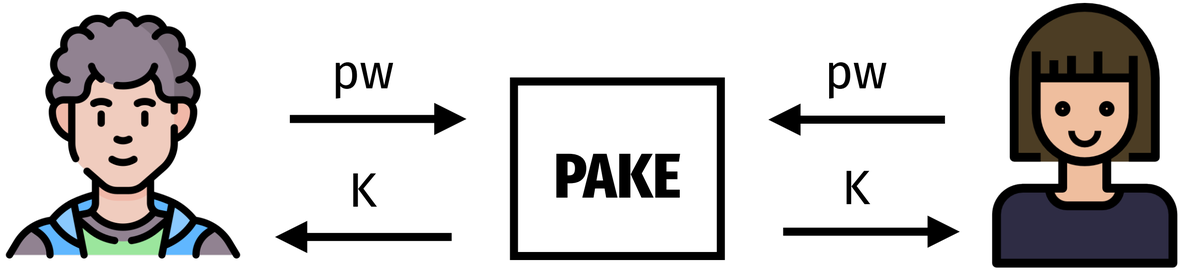

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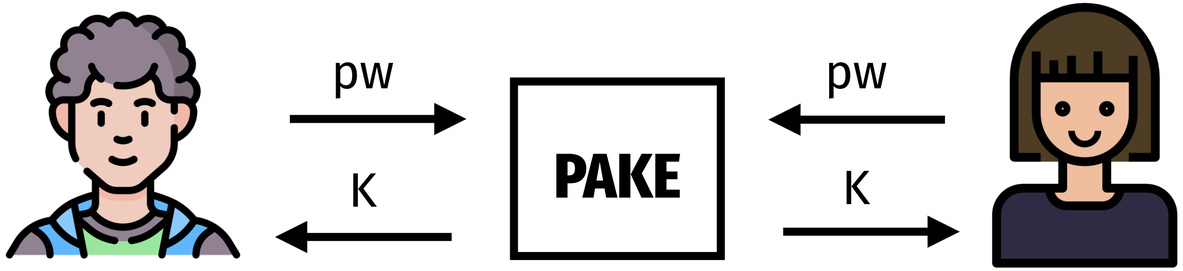

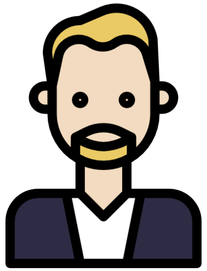

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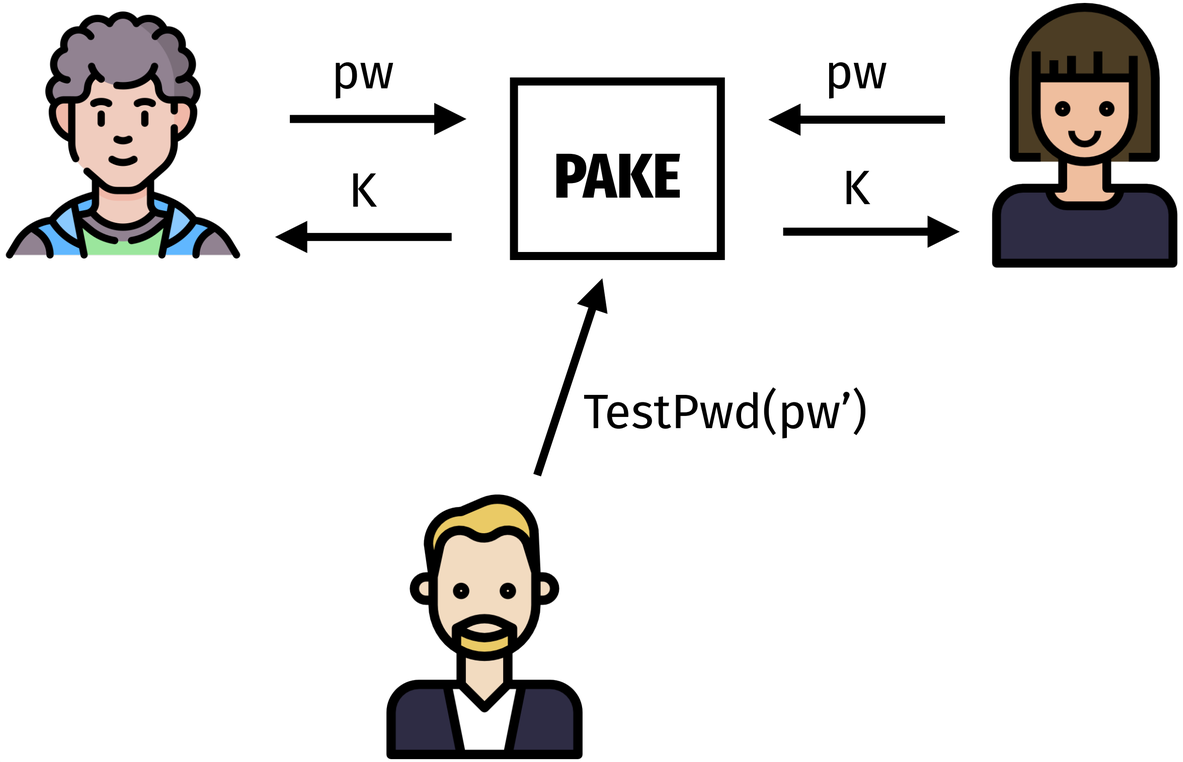

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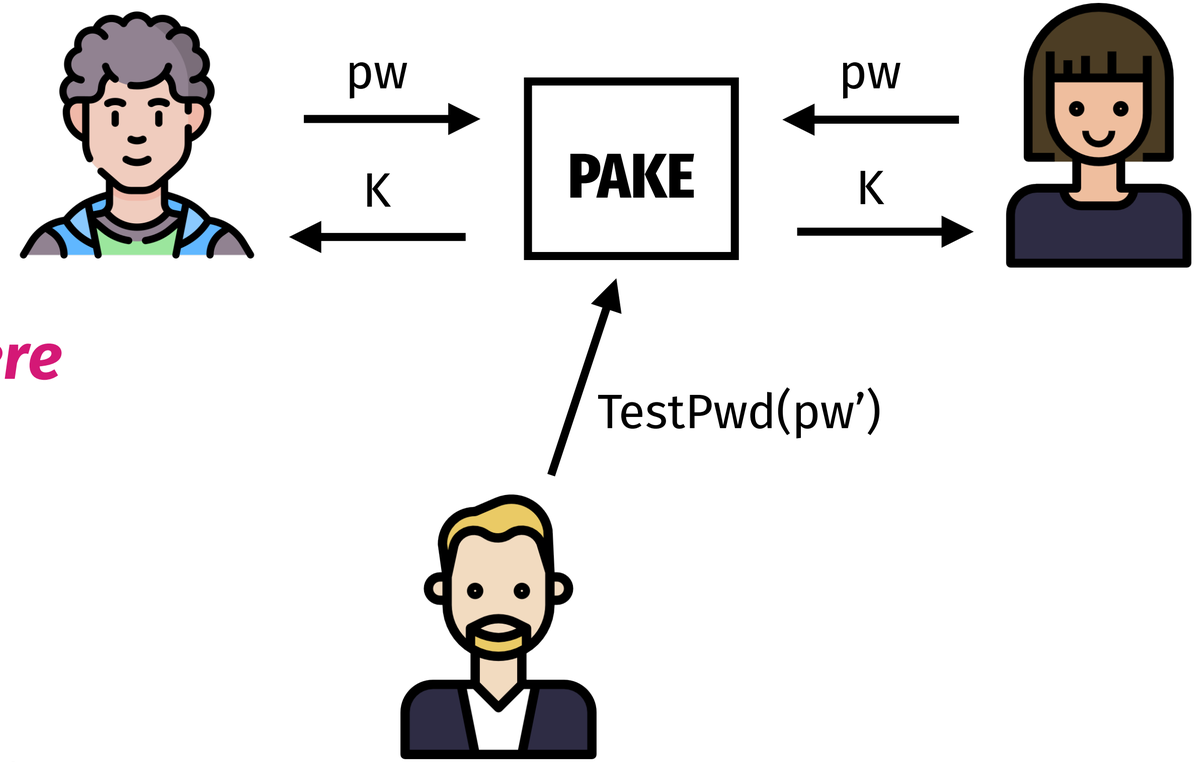
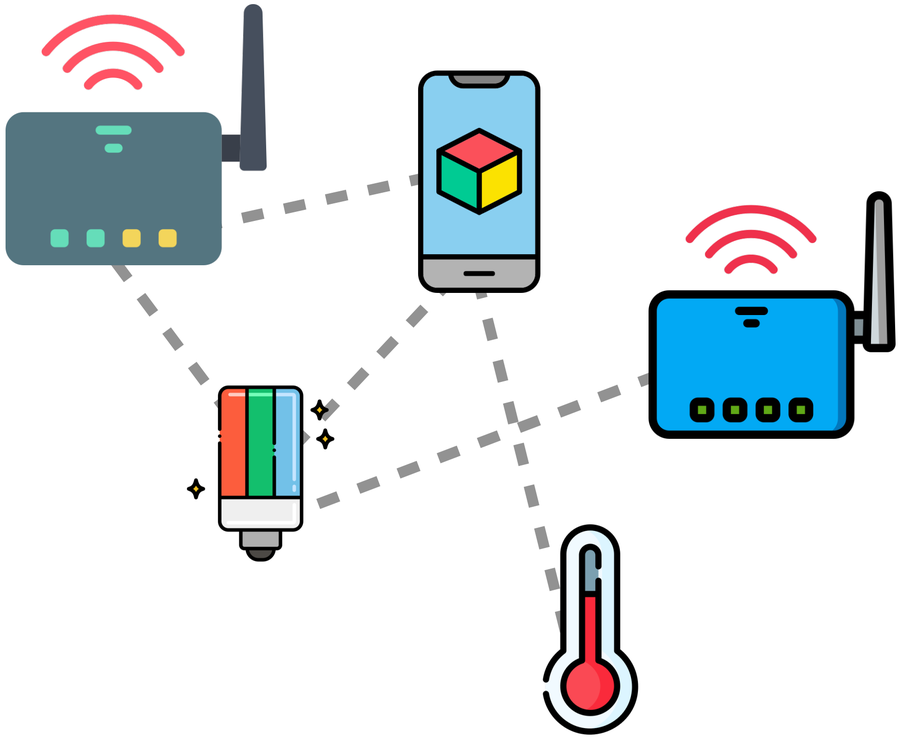


Weird! Cryptographic statements where nothing is high entropy!

PAKEs in IoT



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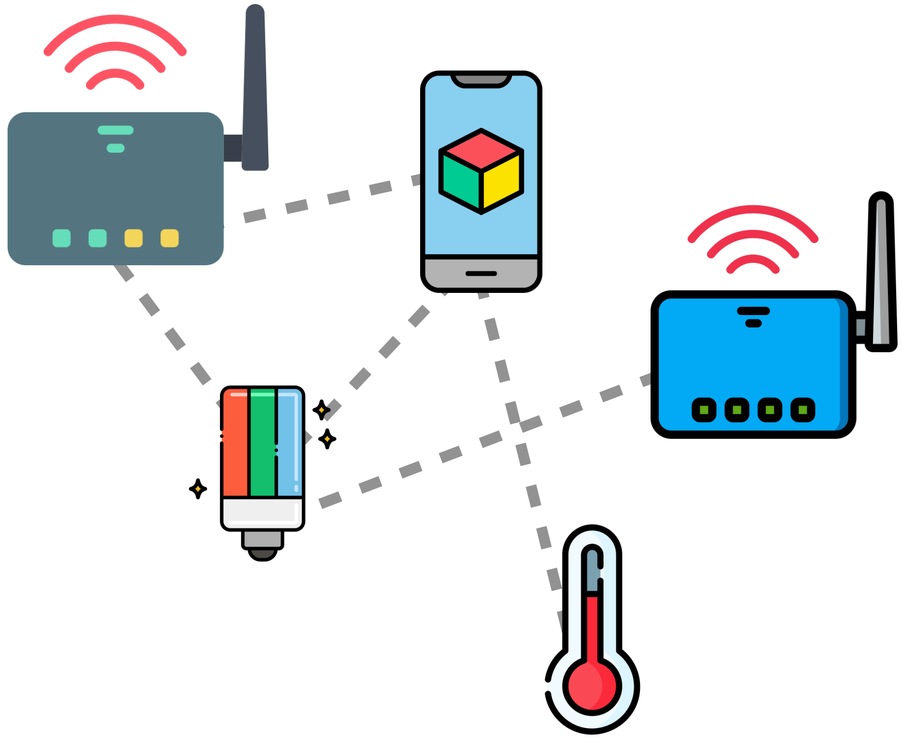

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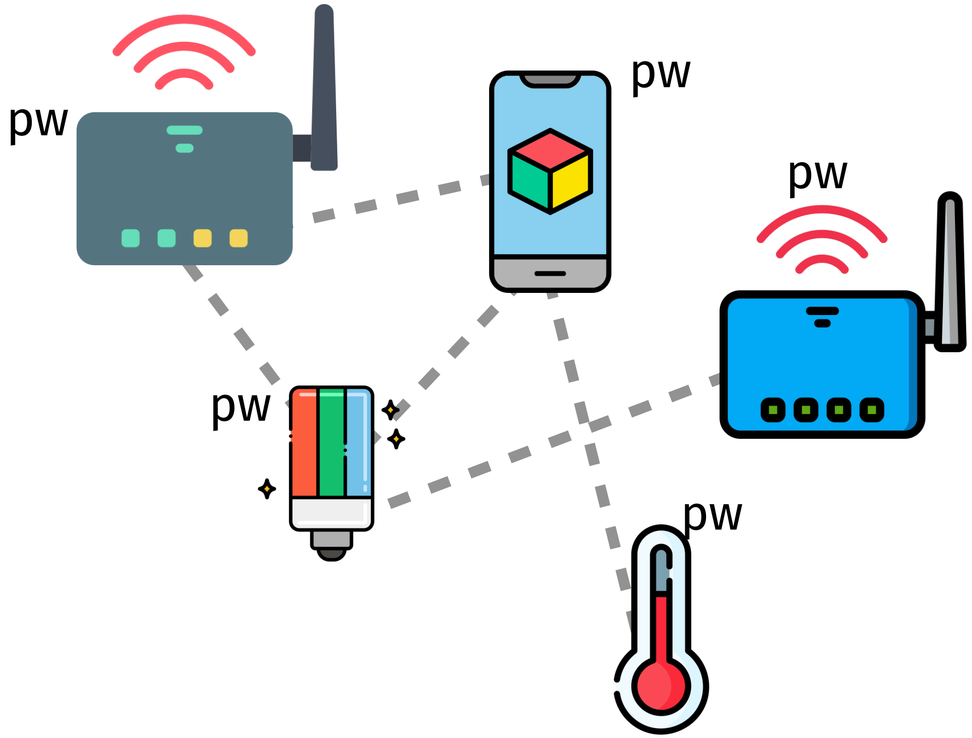

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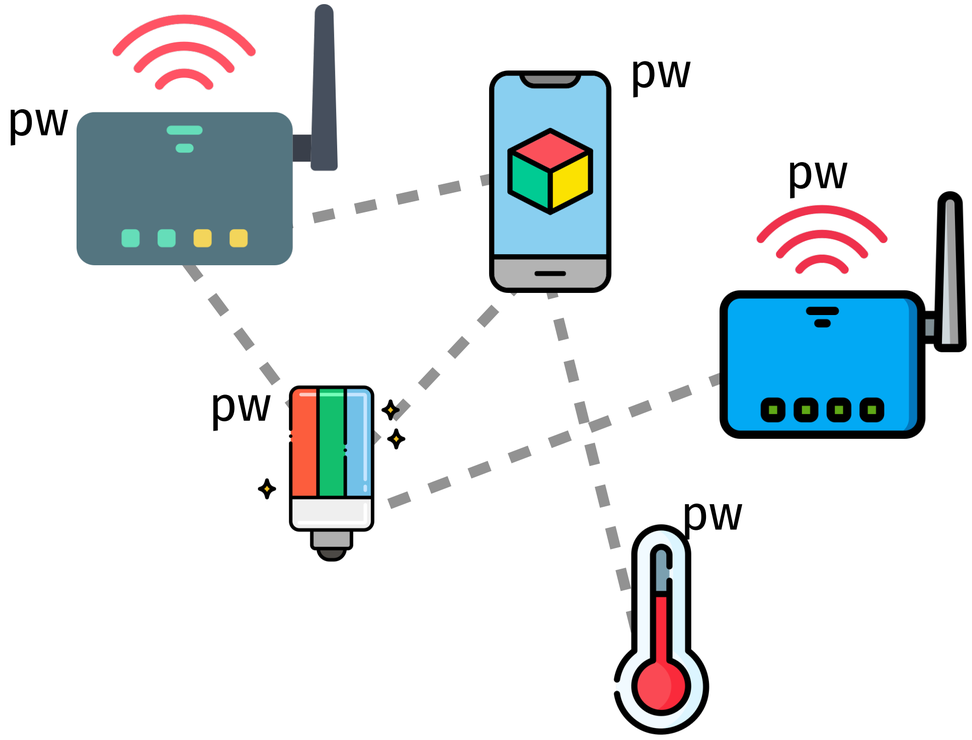

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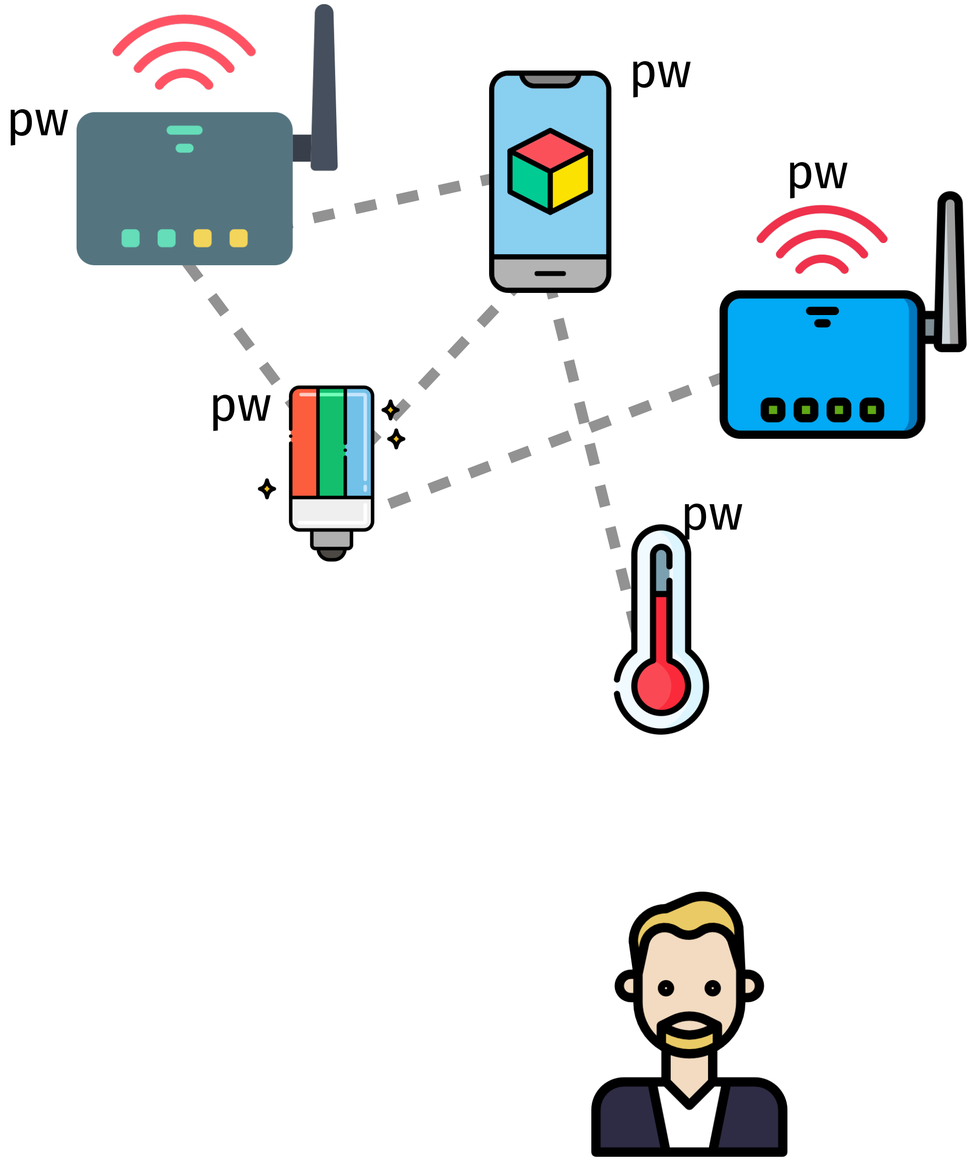

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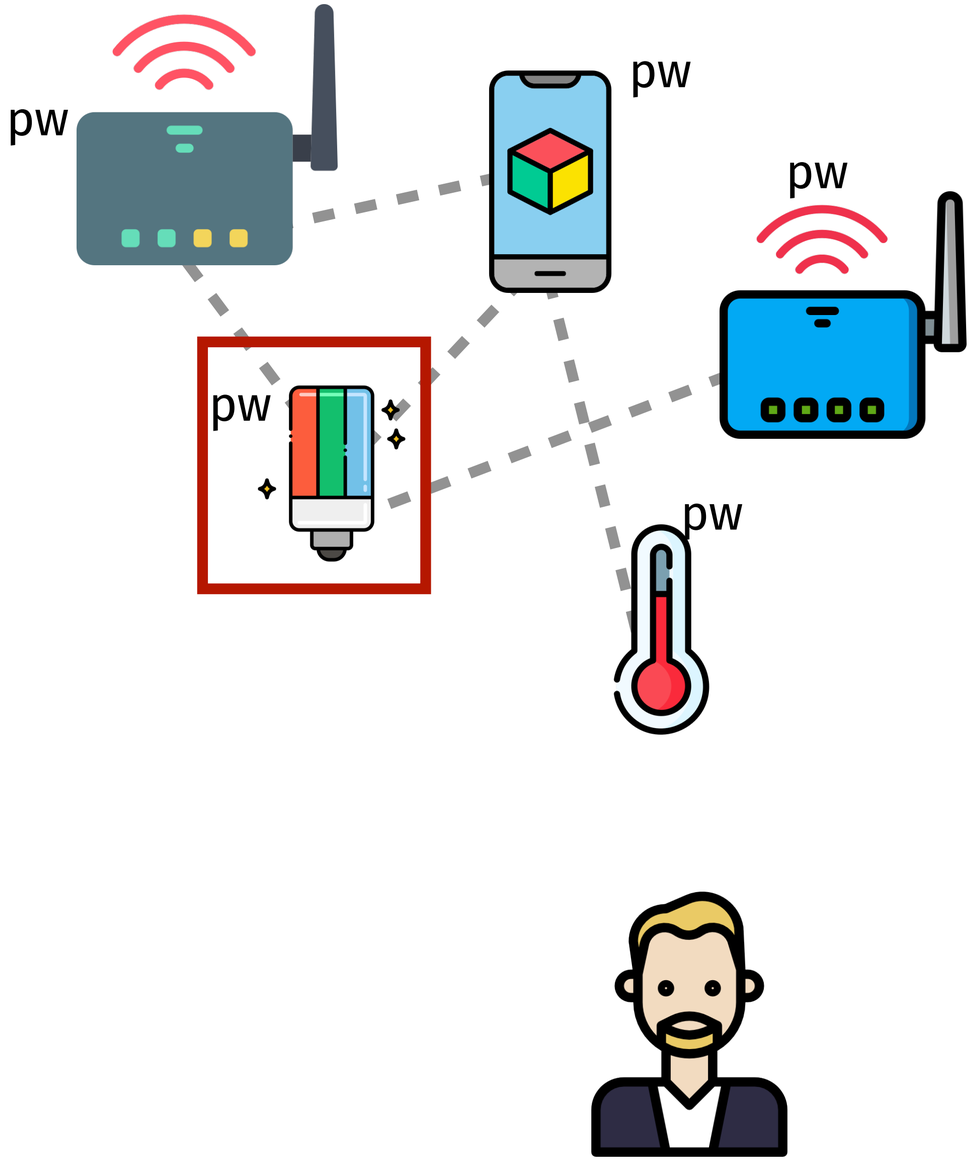

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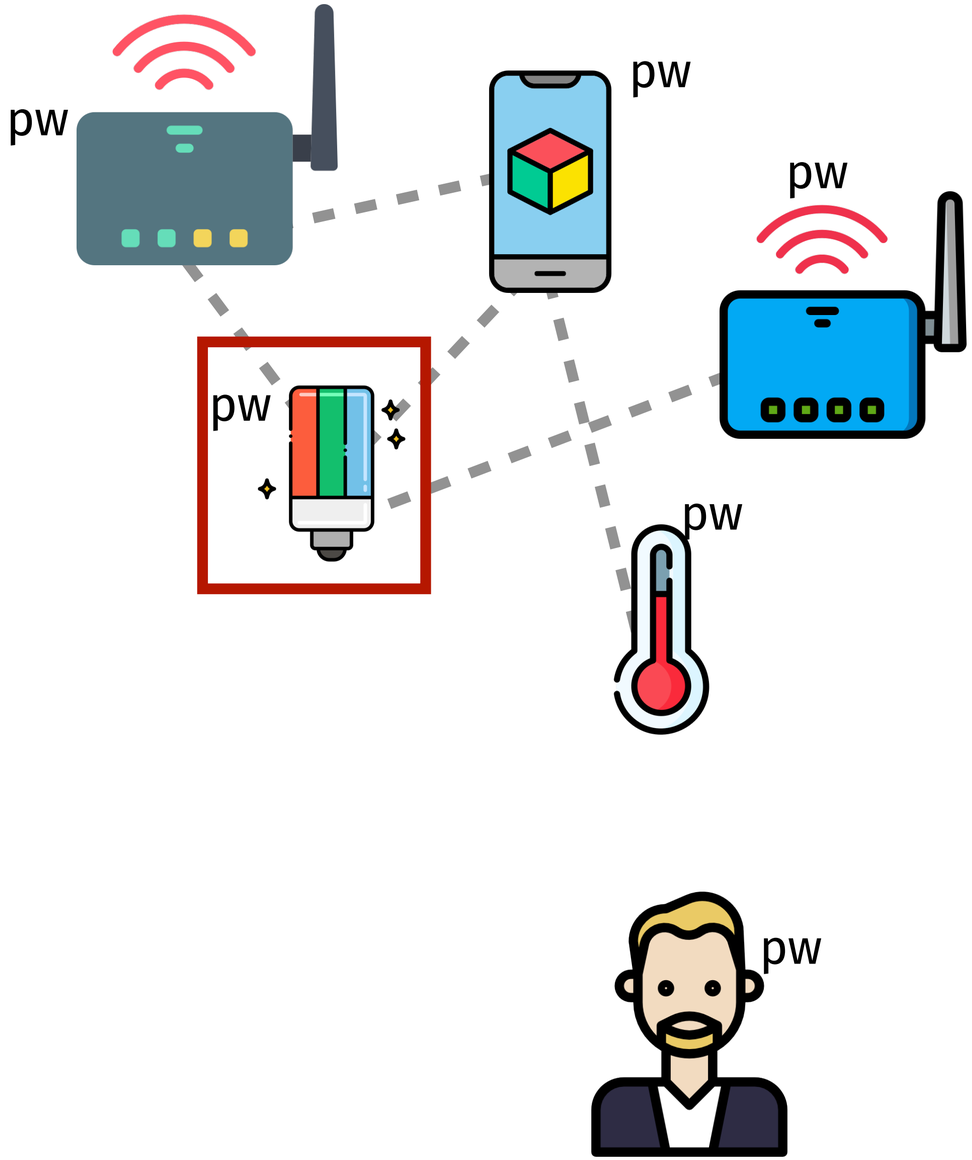

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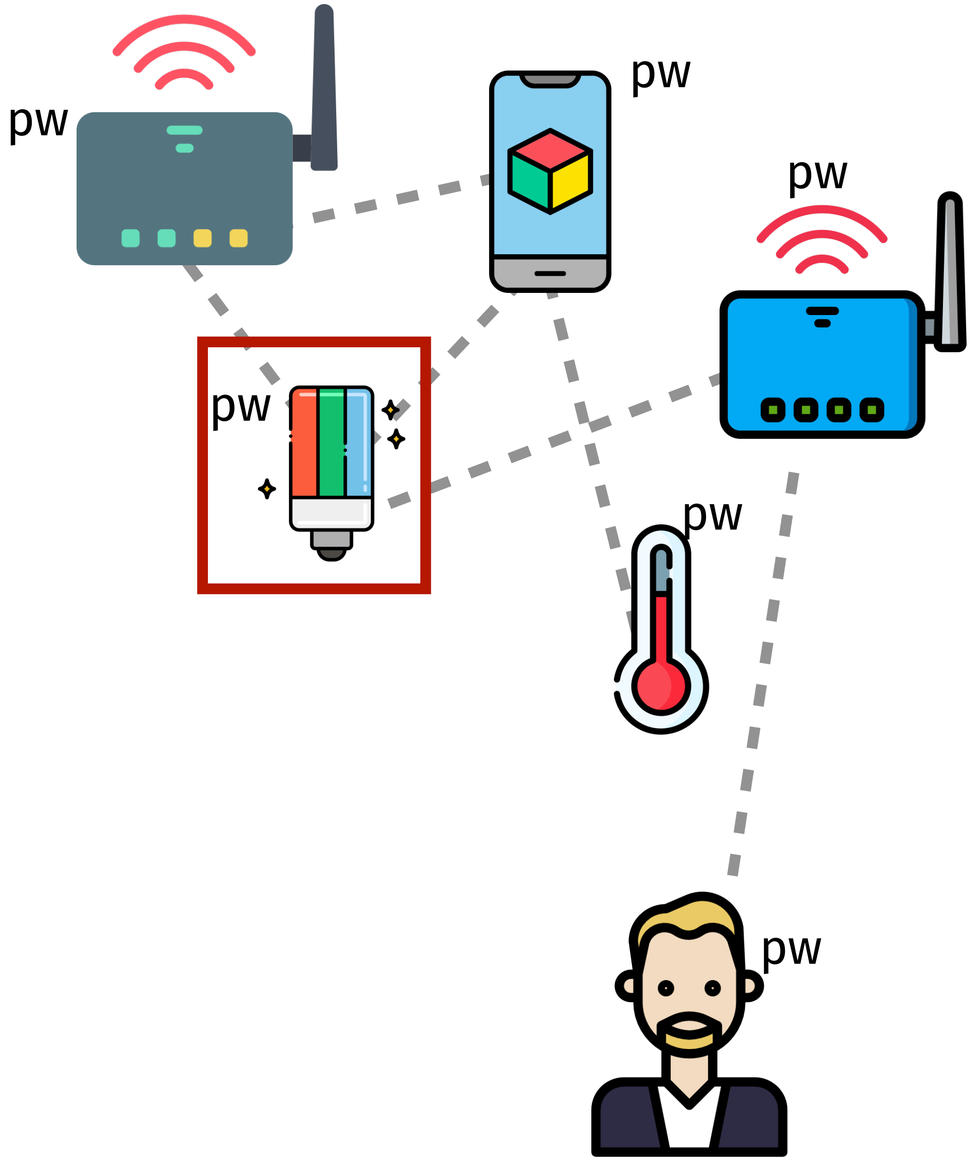

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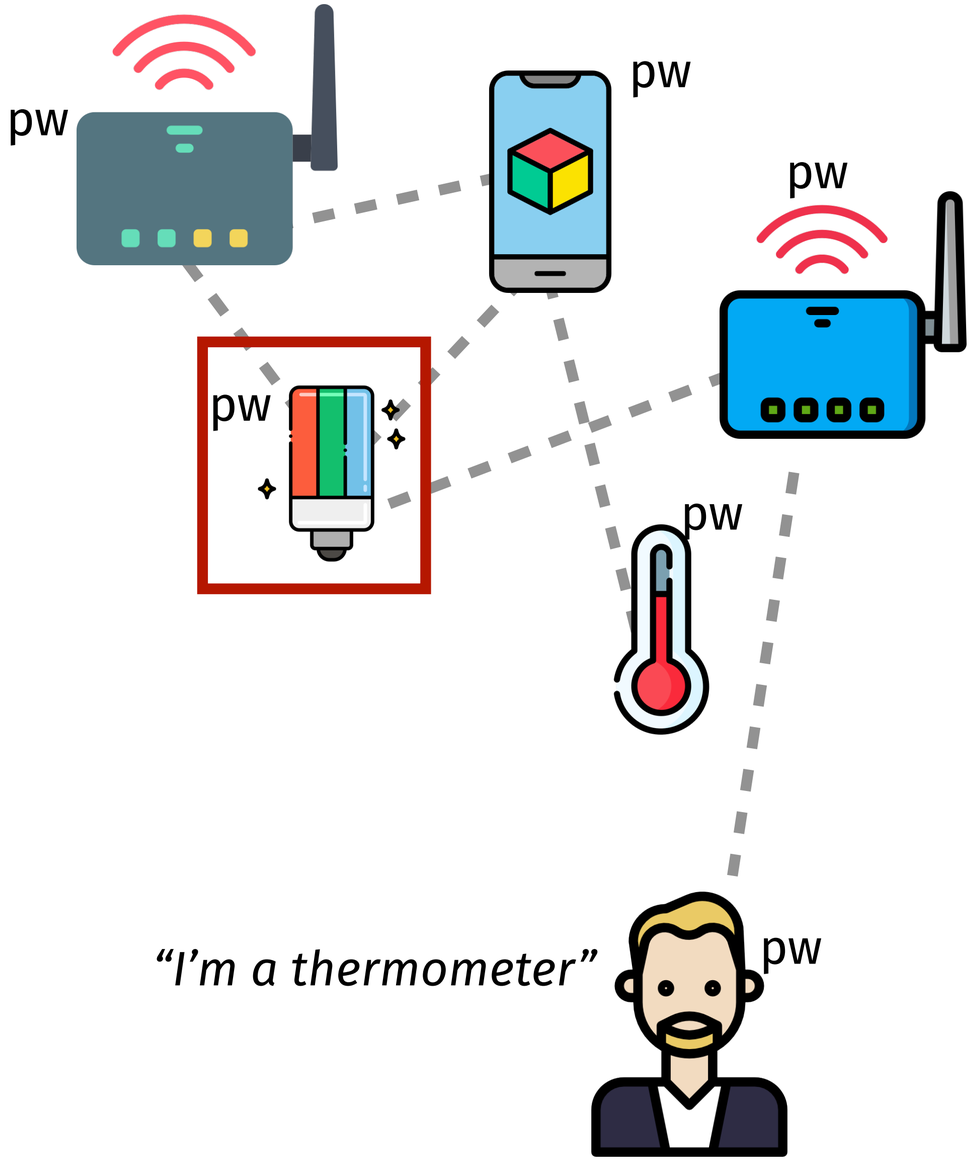

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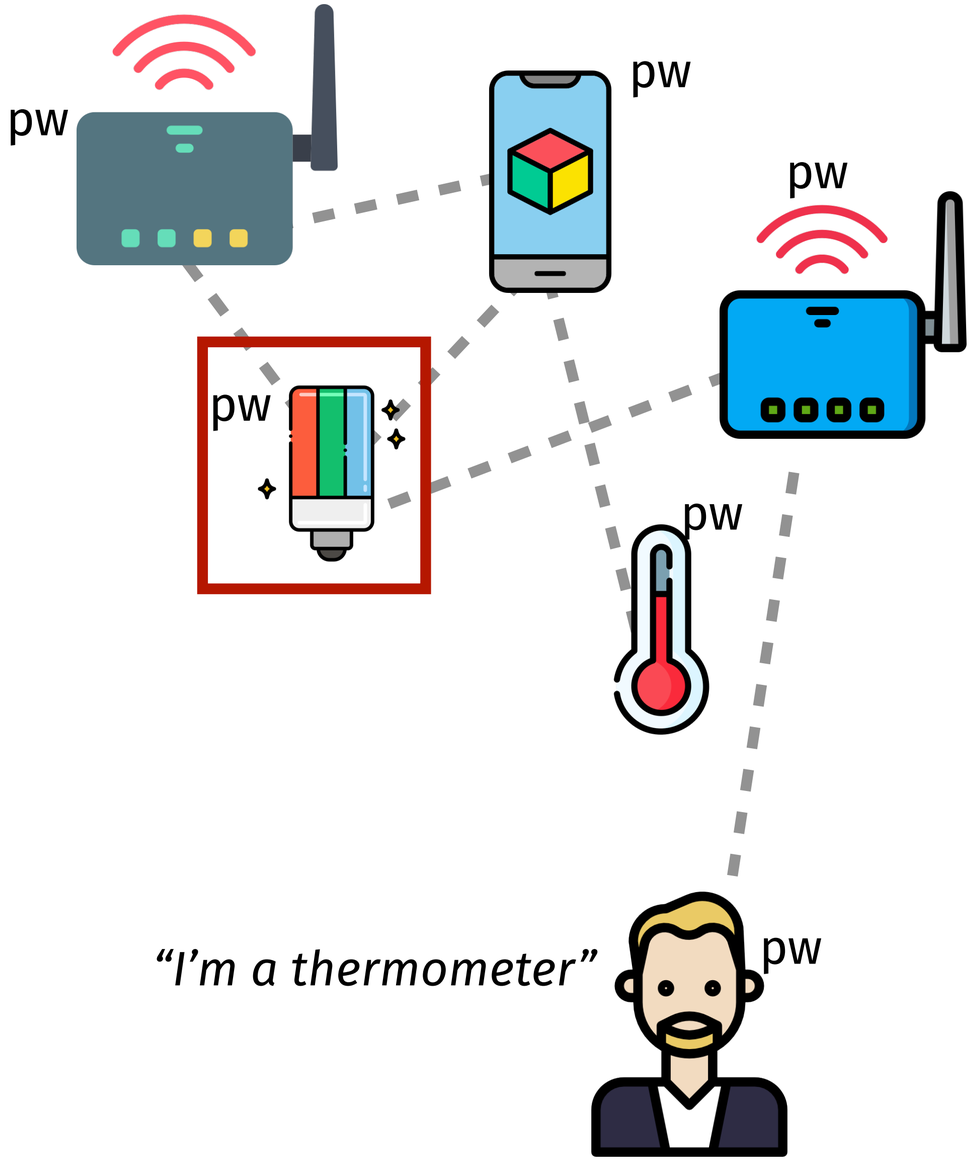

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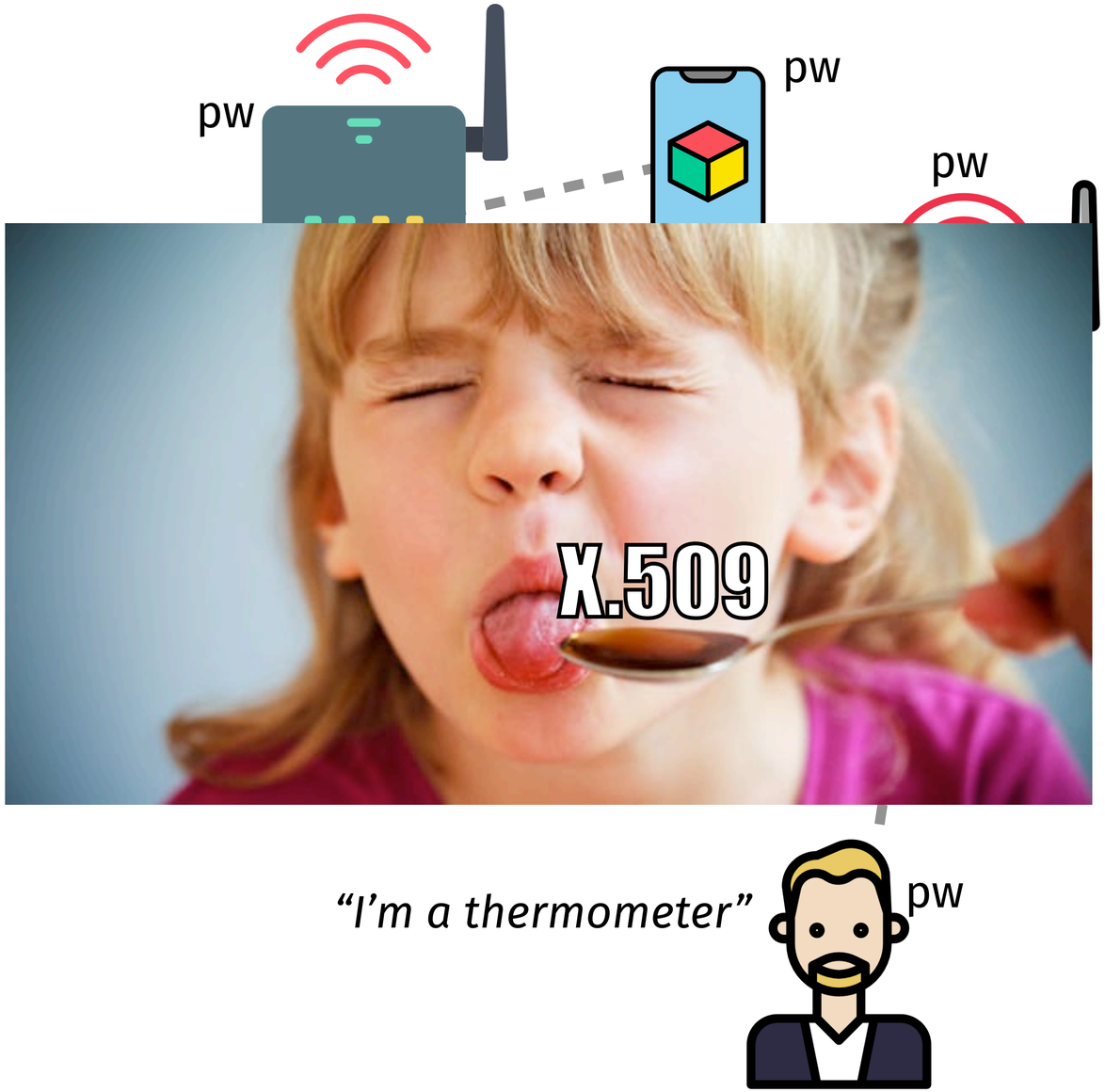

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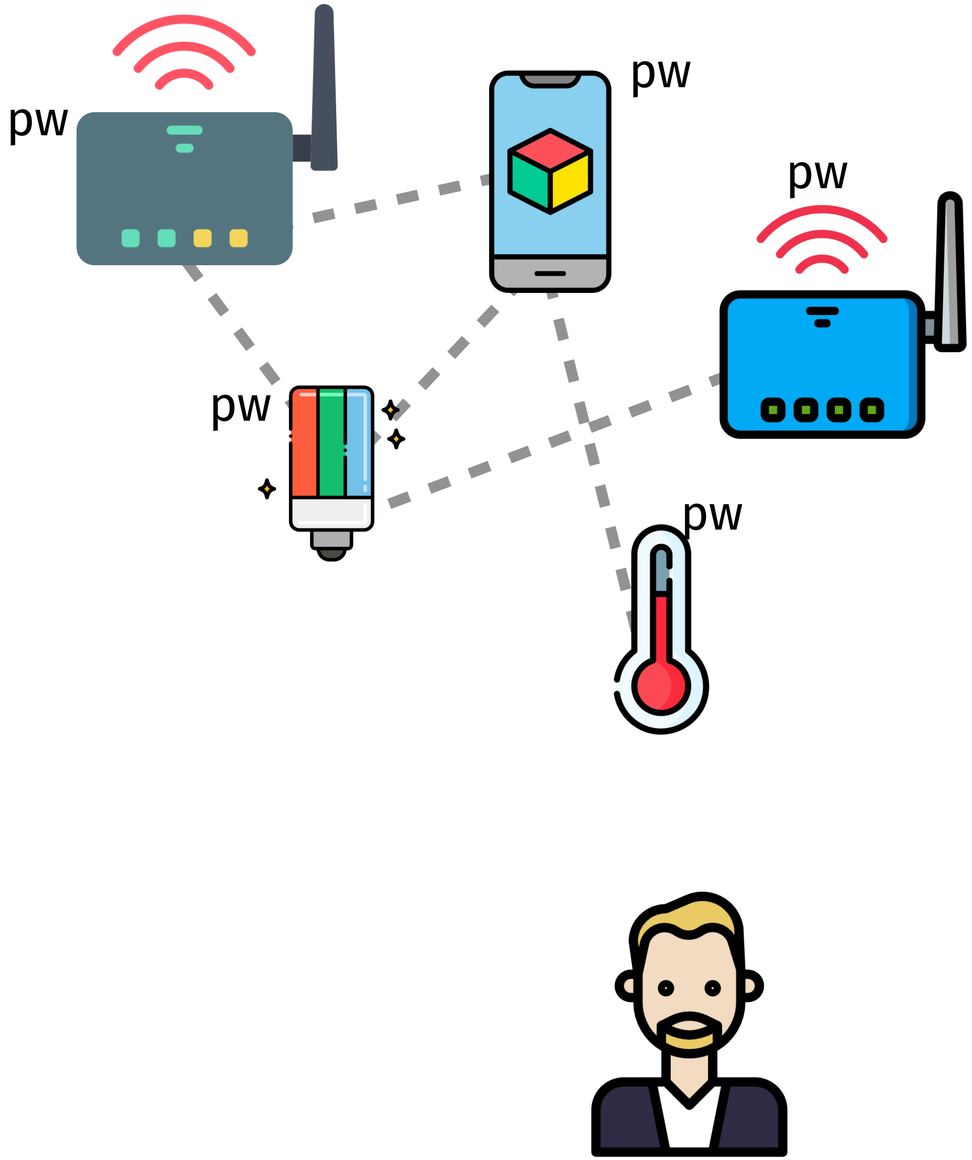

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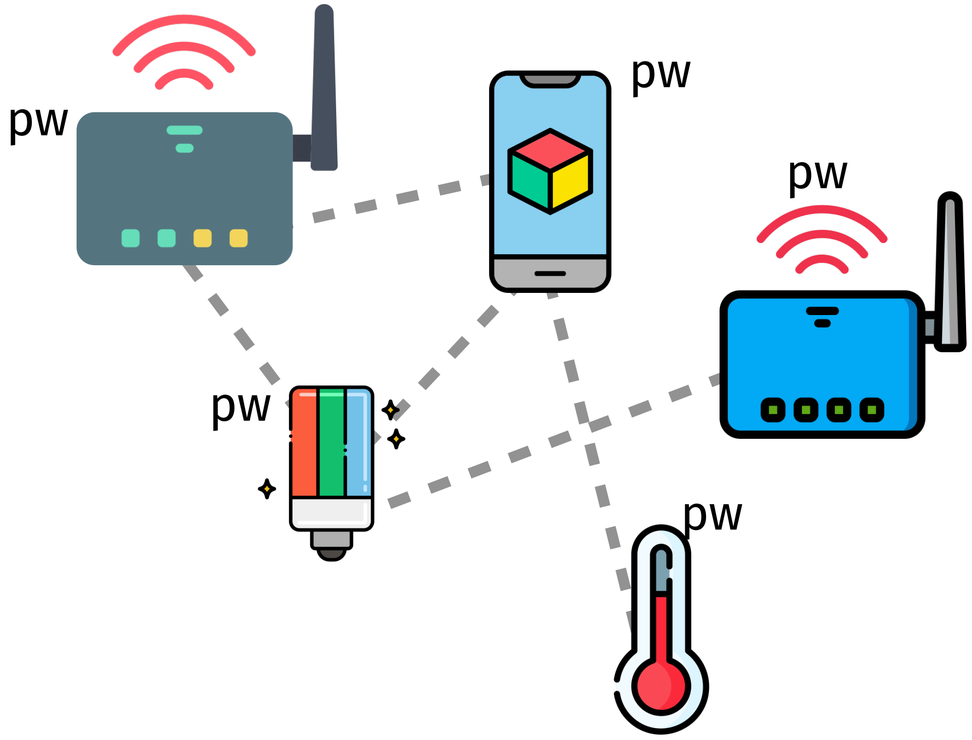

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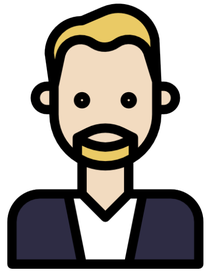

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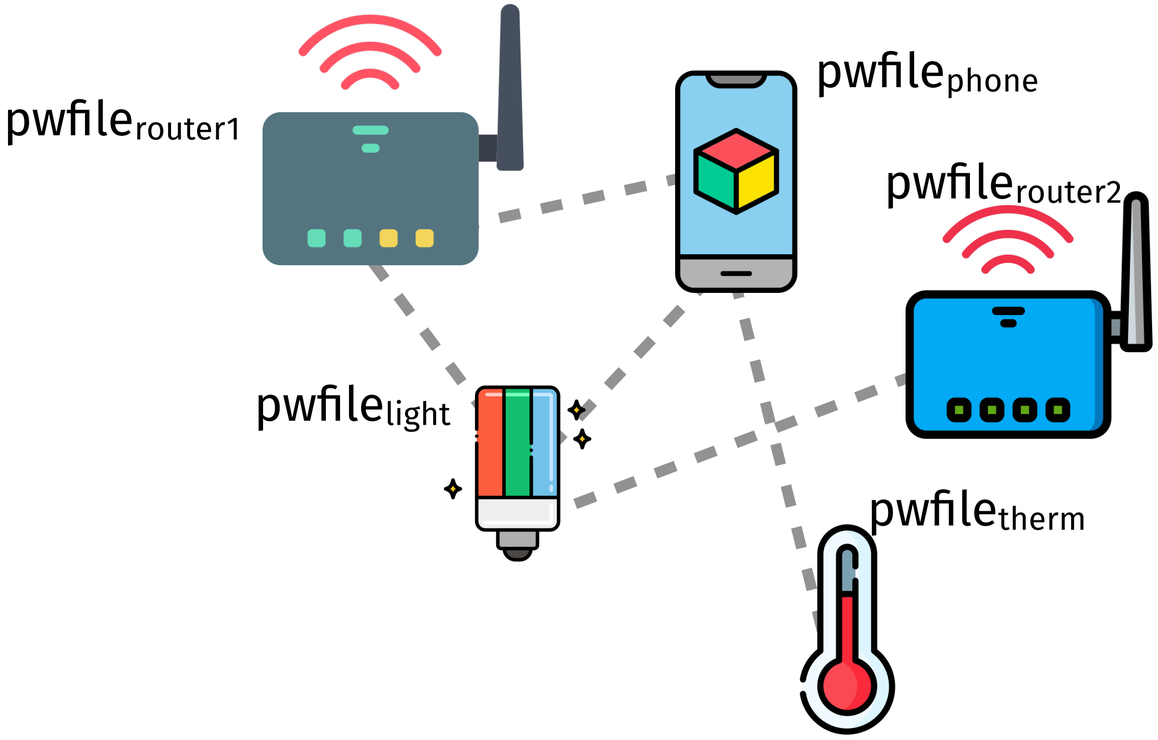

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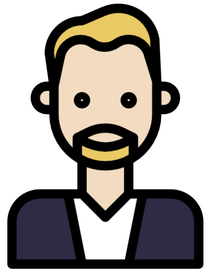

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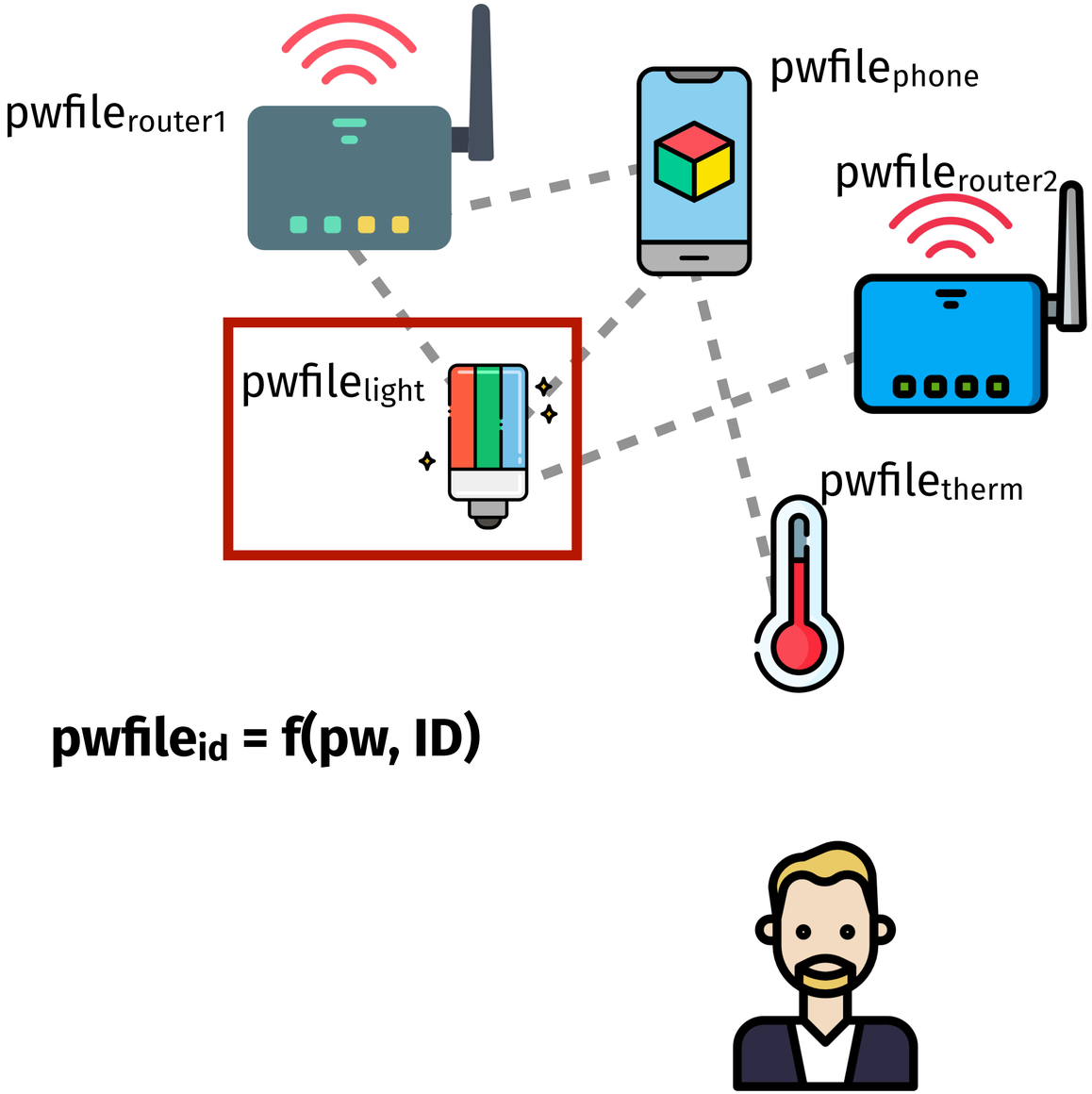

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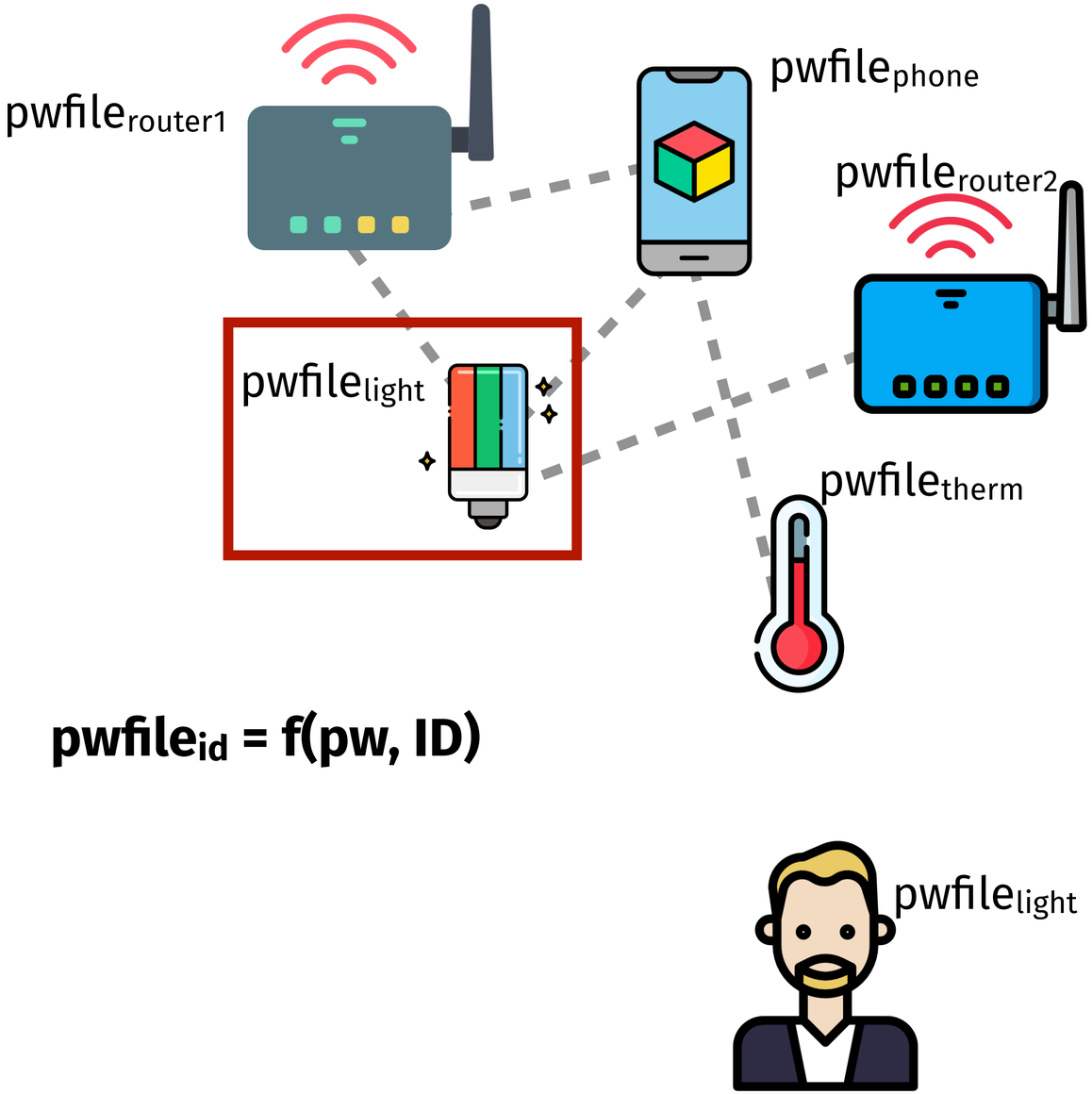

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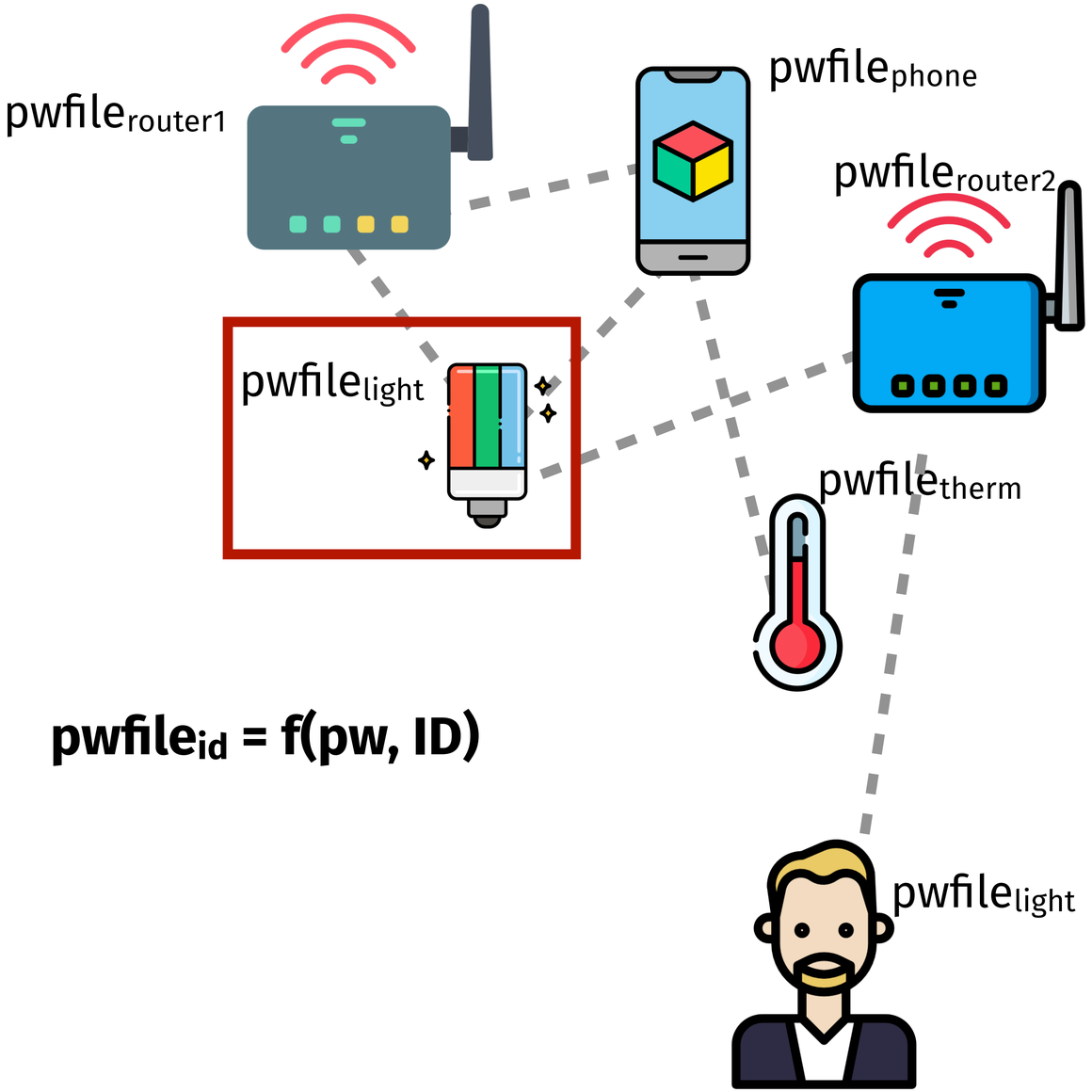

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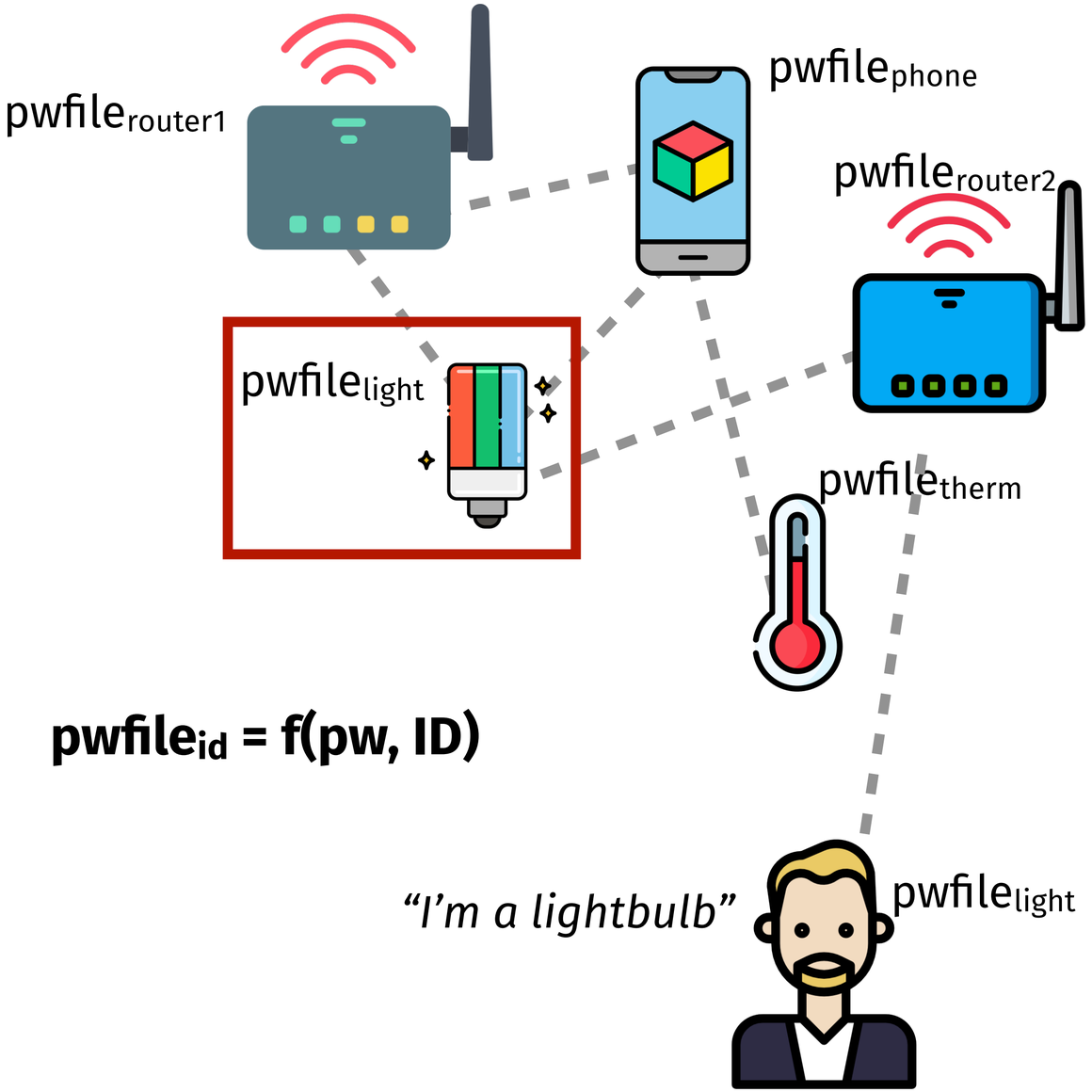

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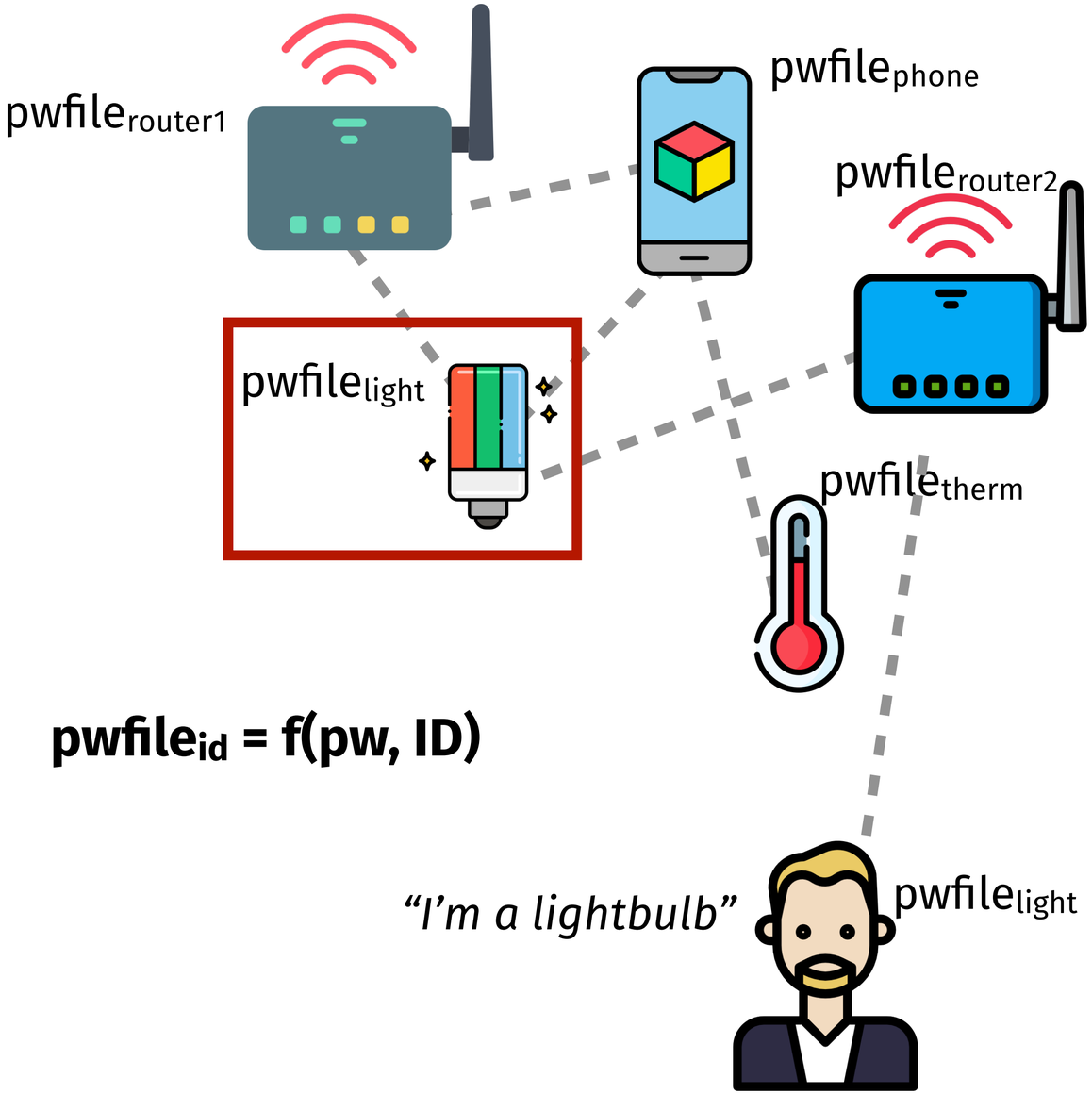
This is called an **identity-binding PAKE** (iPAKE) [CNPR22]



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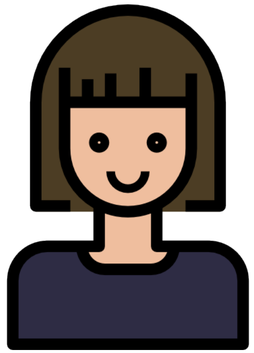

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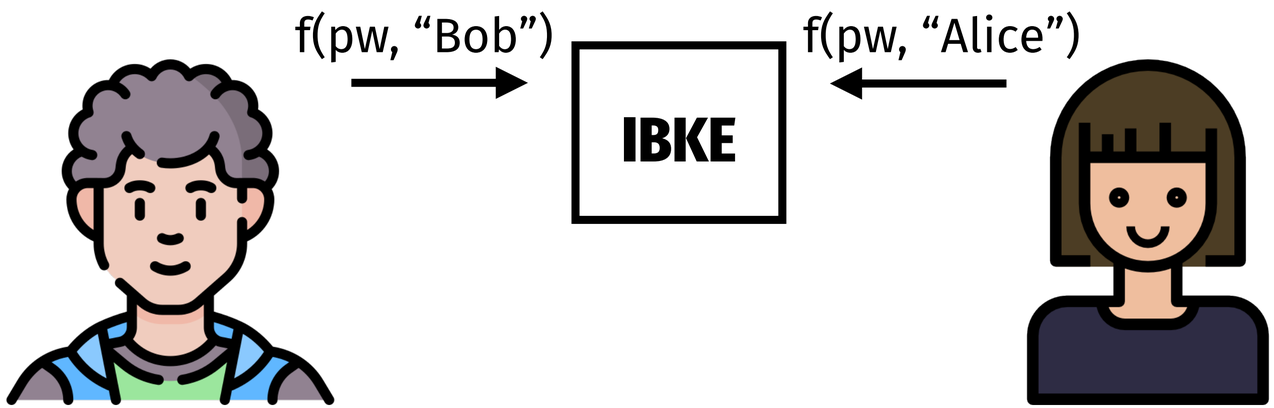

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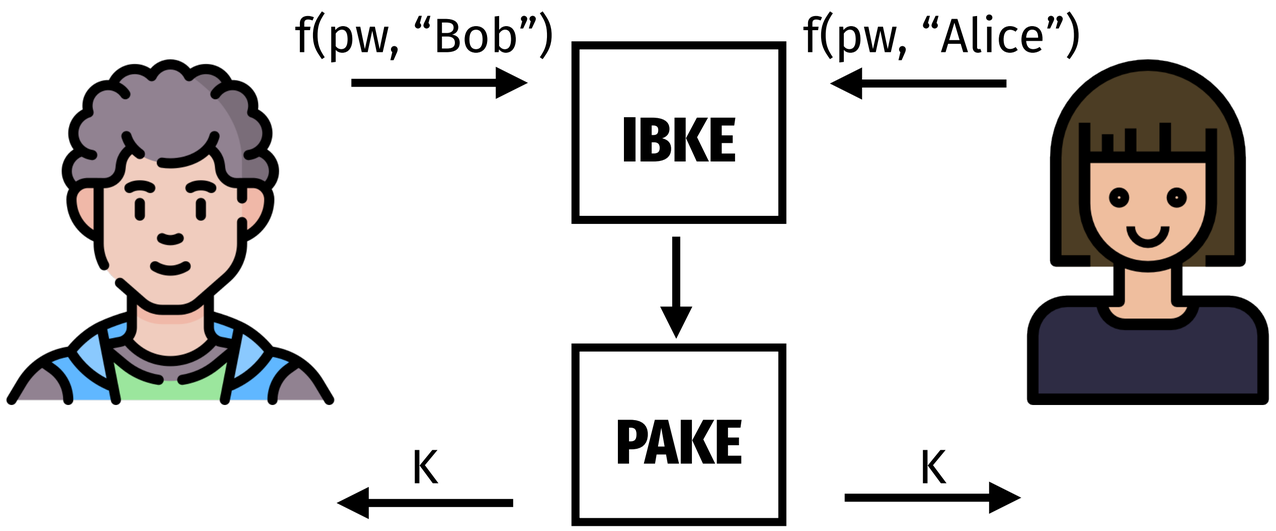

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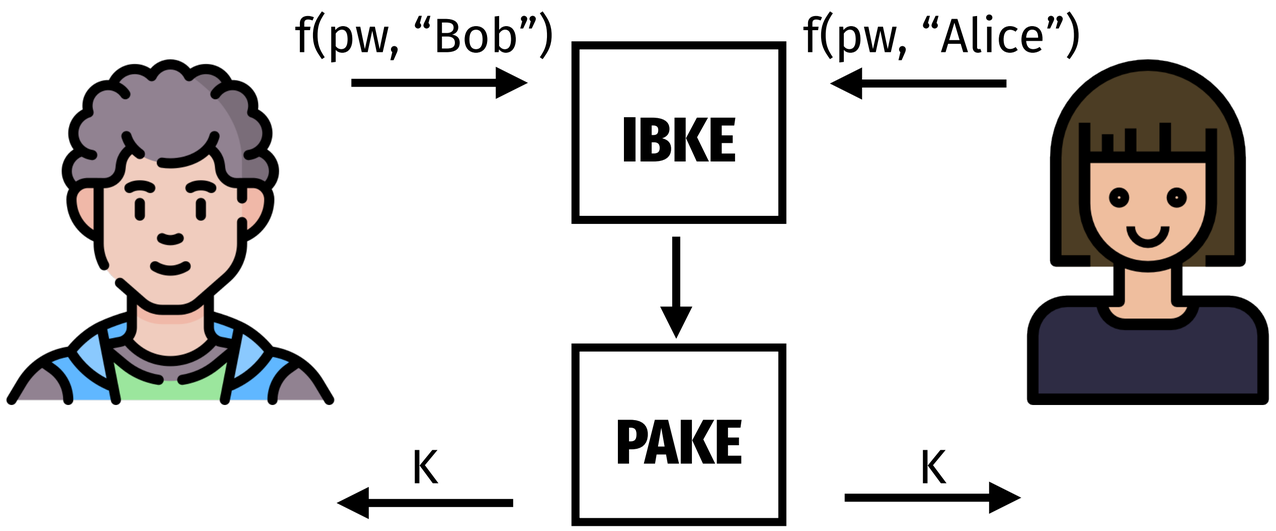

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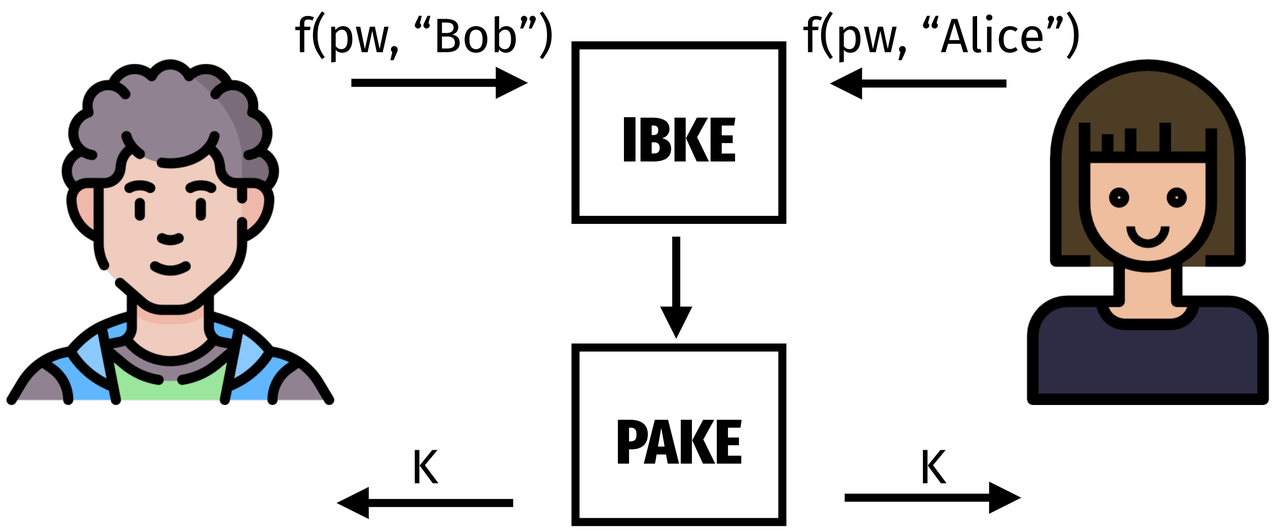
Cannot be made PQ!



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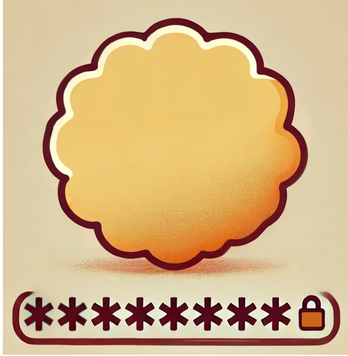

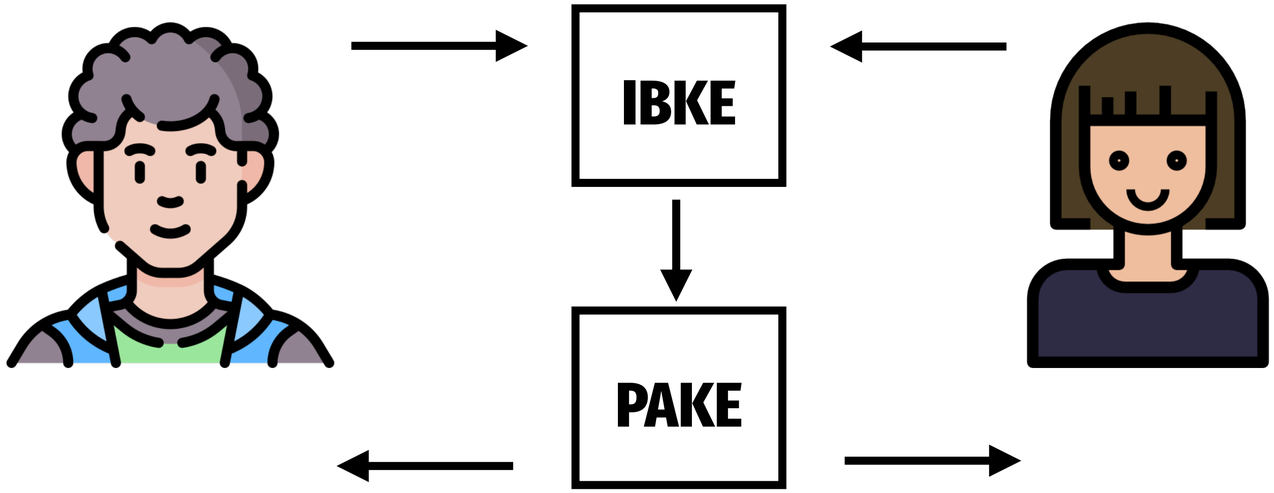

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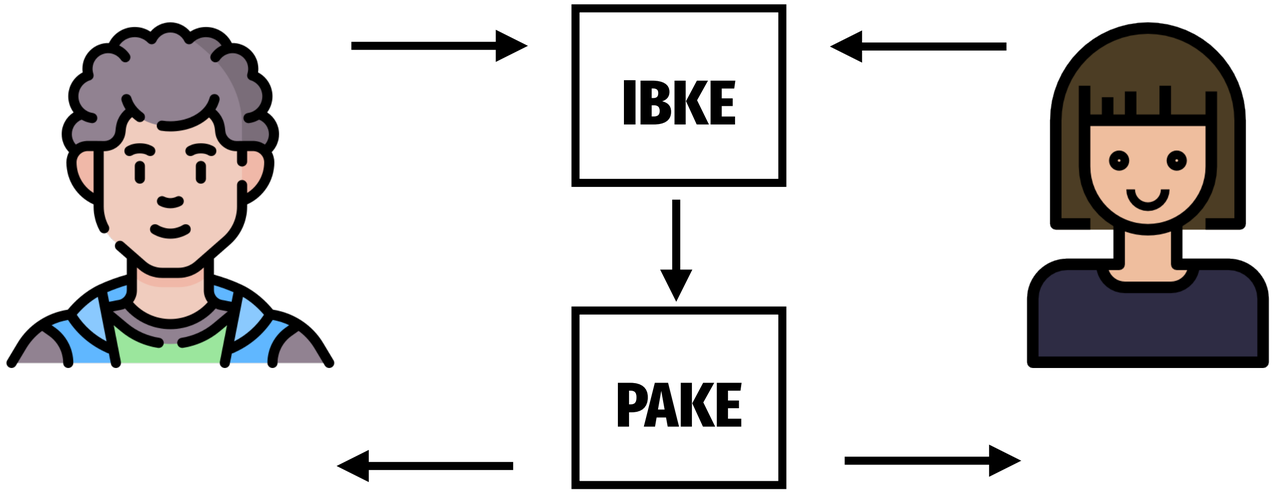

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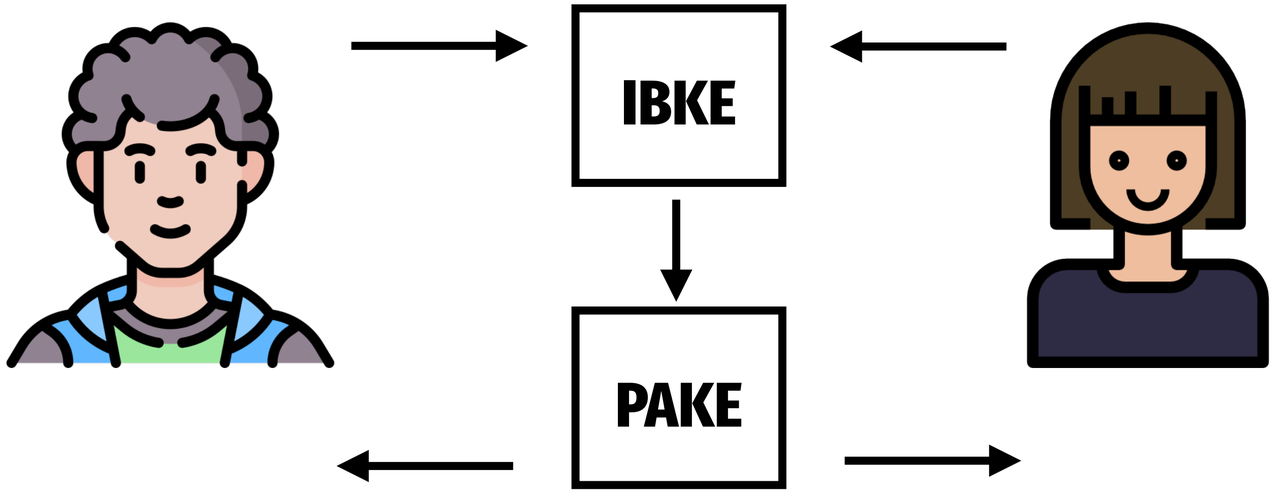

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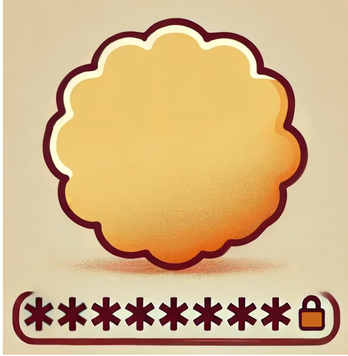

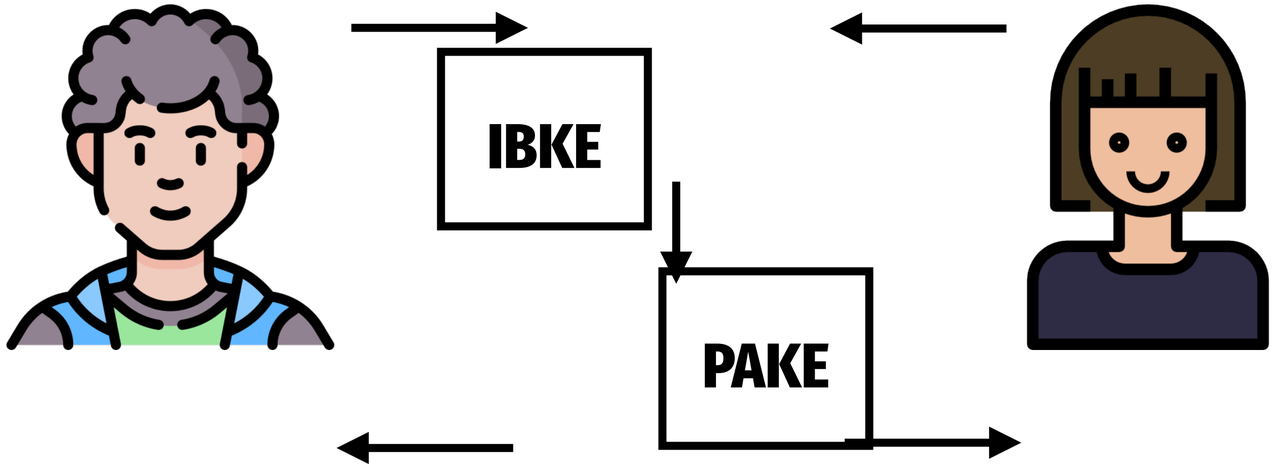

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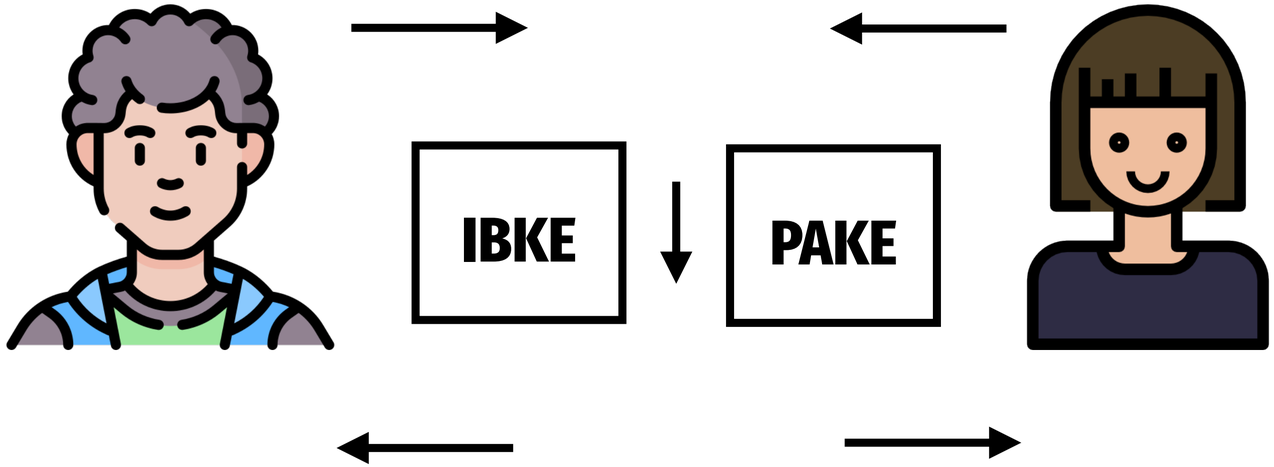

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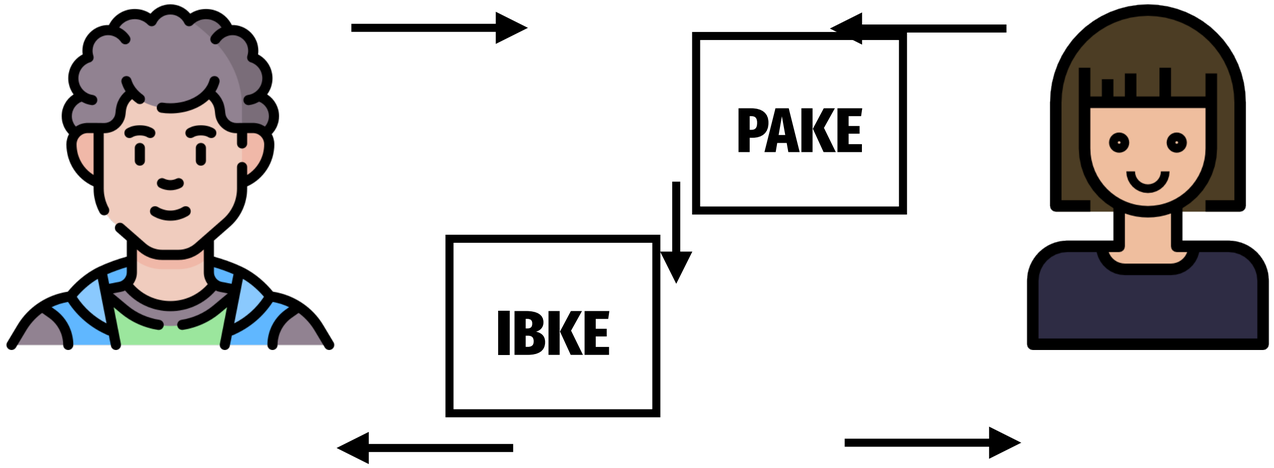

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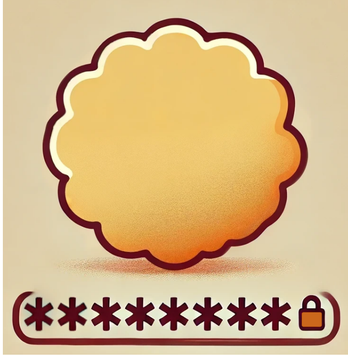

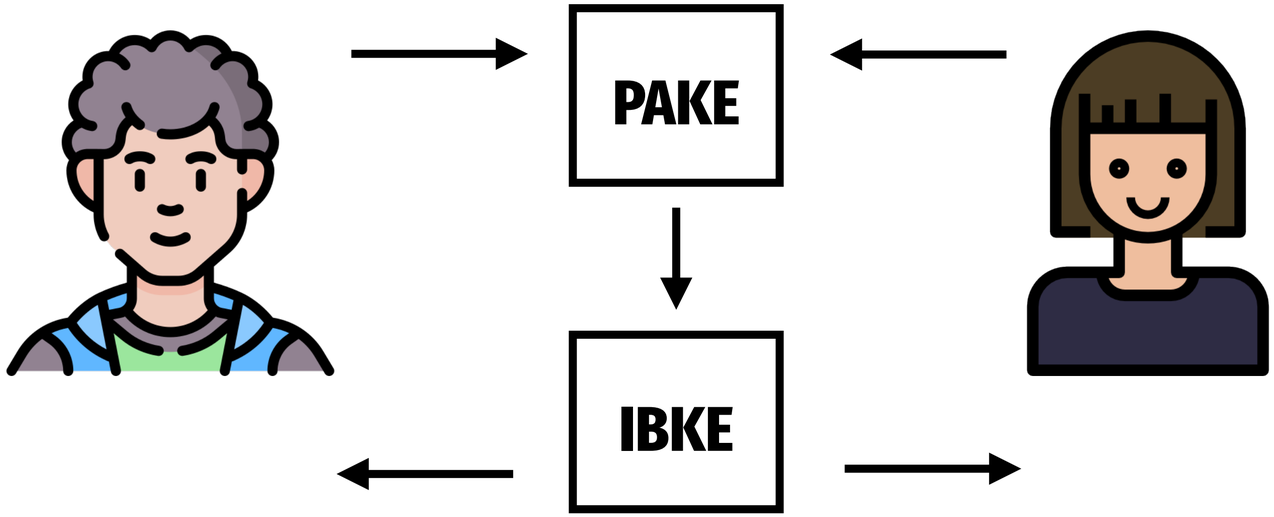

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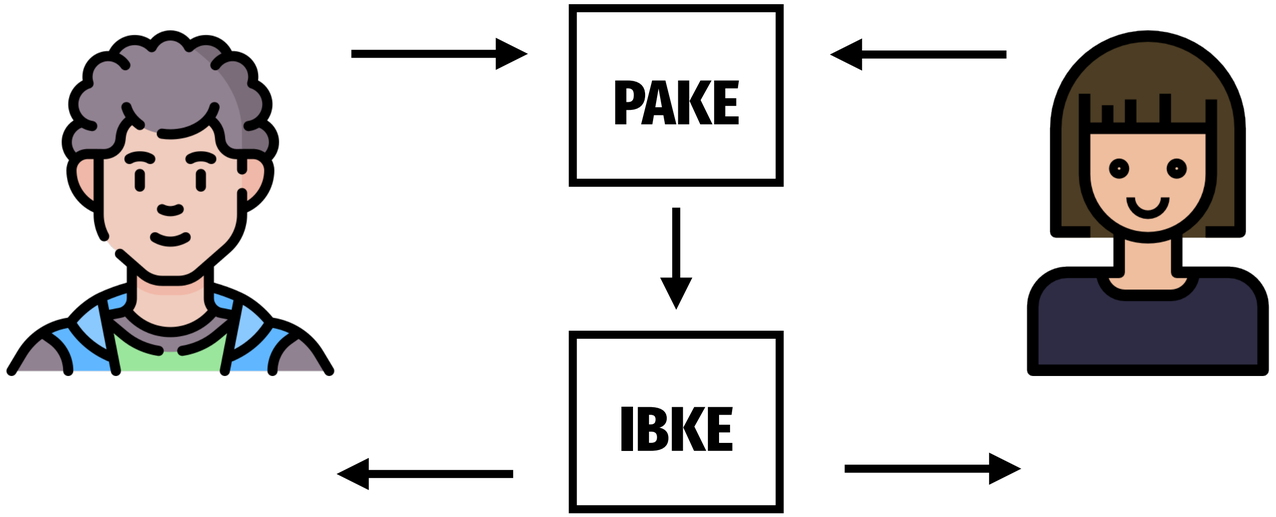

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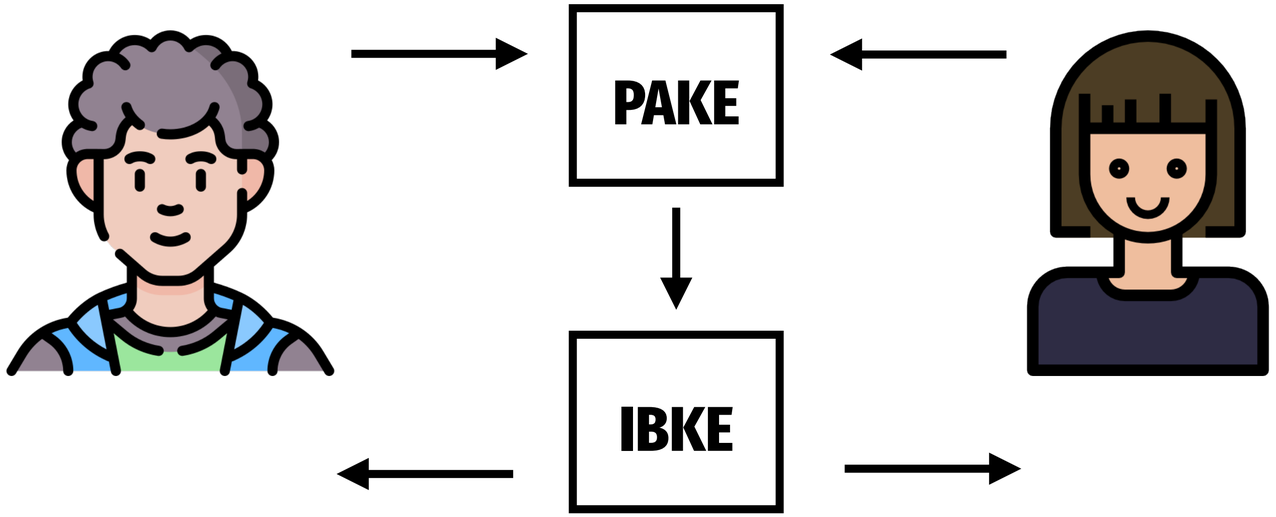

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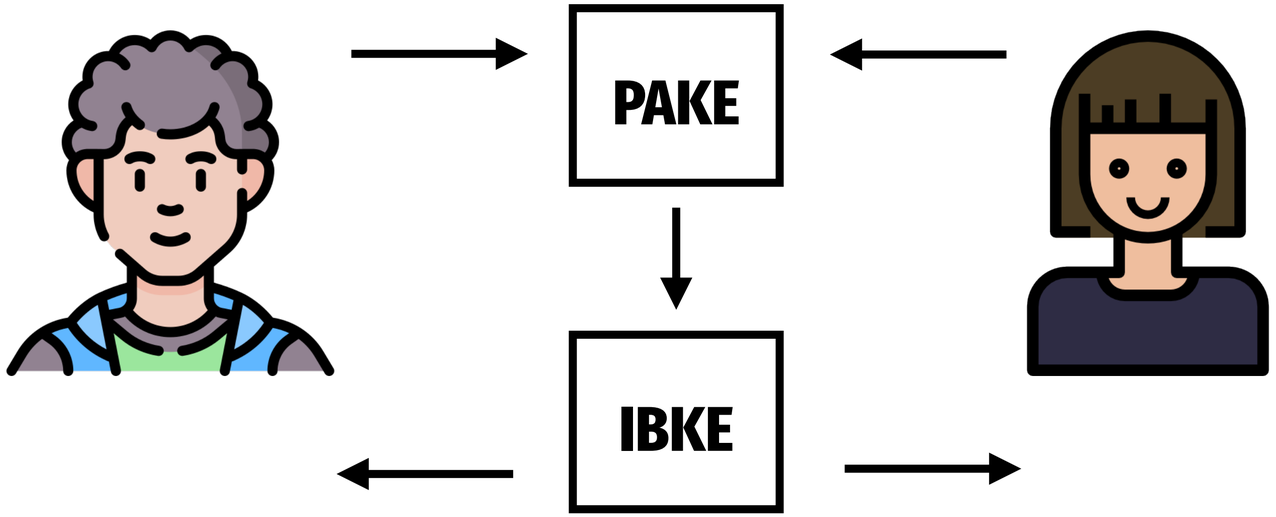

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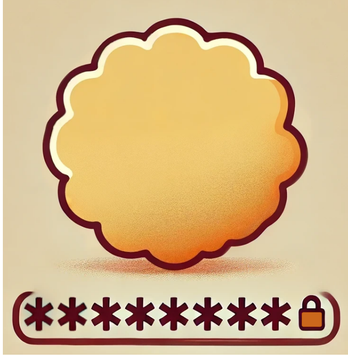

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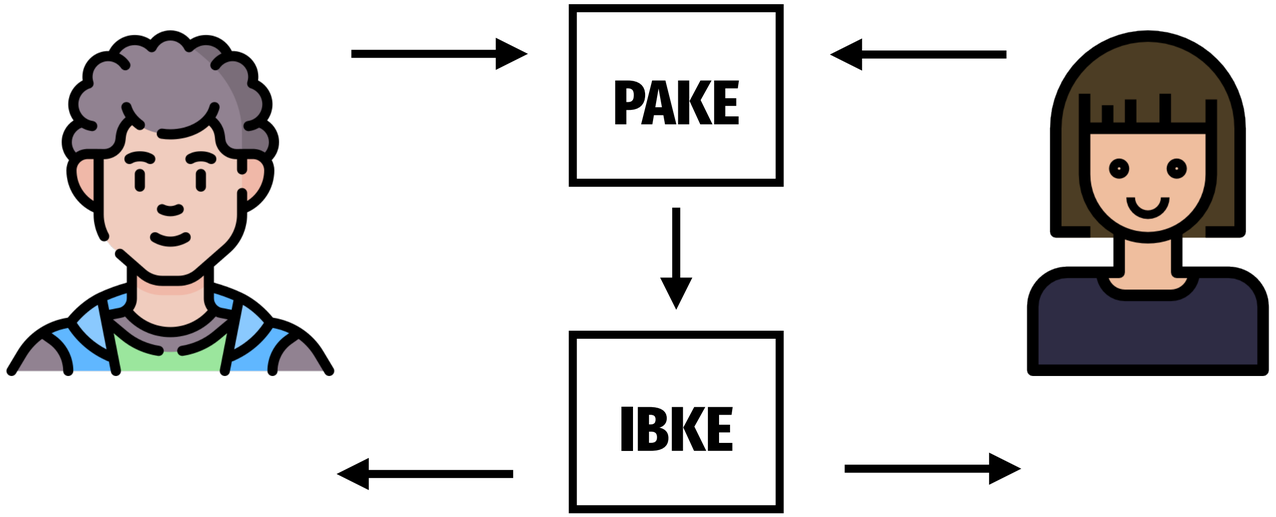

Post-quantum LATKE is **only 3% slower** than pre-quantum CHIP (ignoring comms costs)

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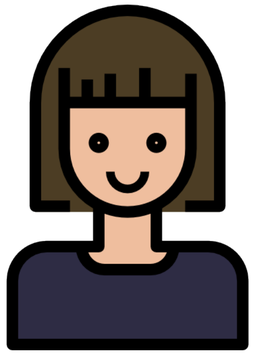

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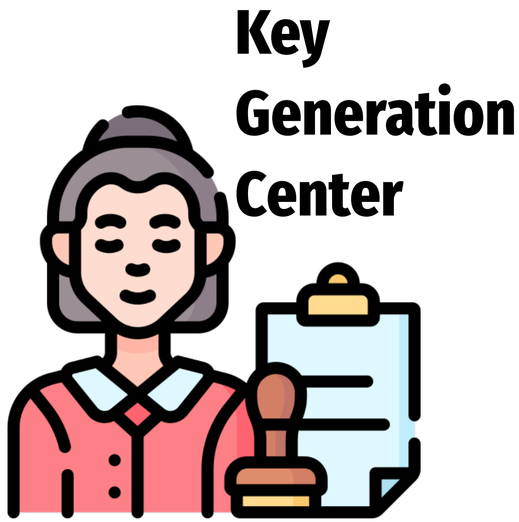

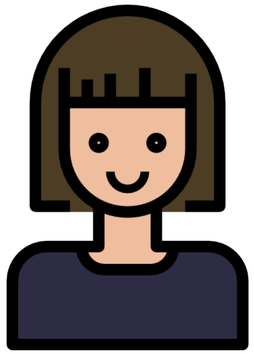

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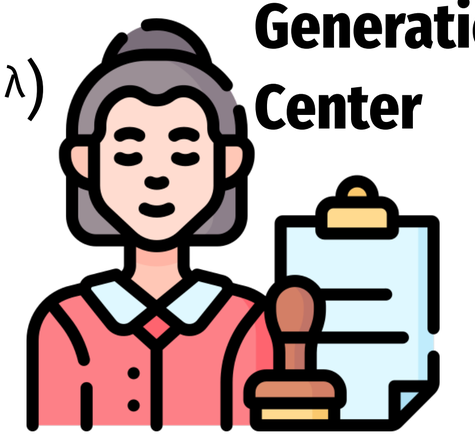

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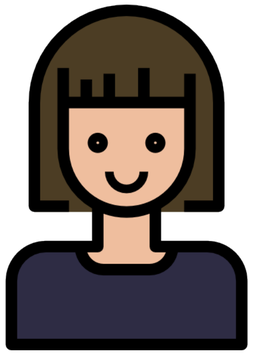

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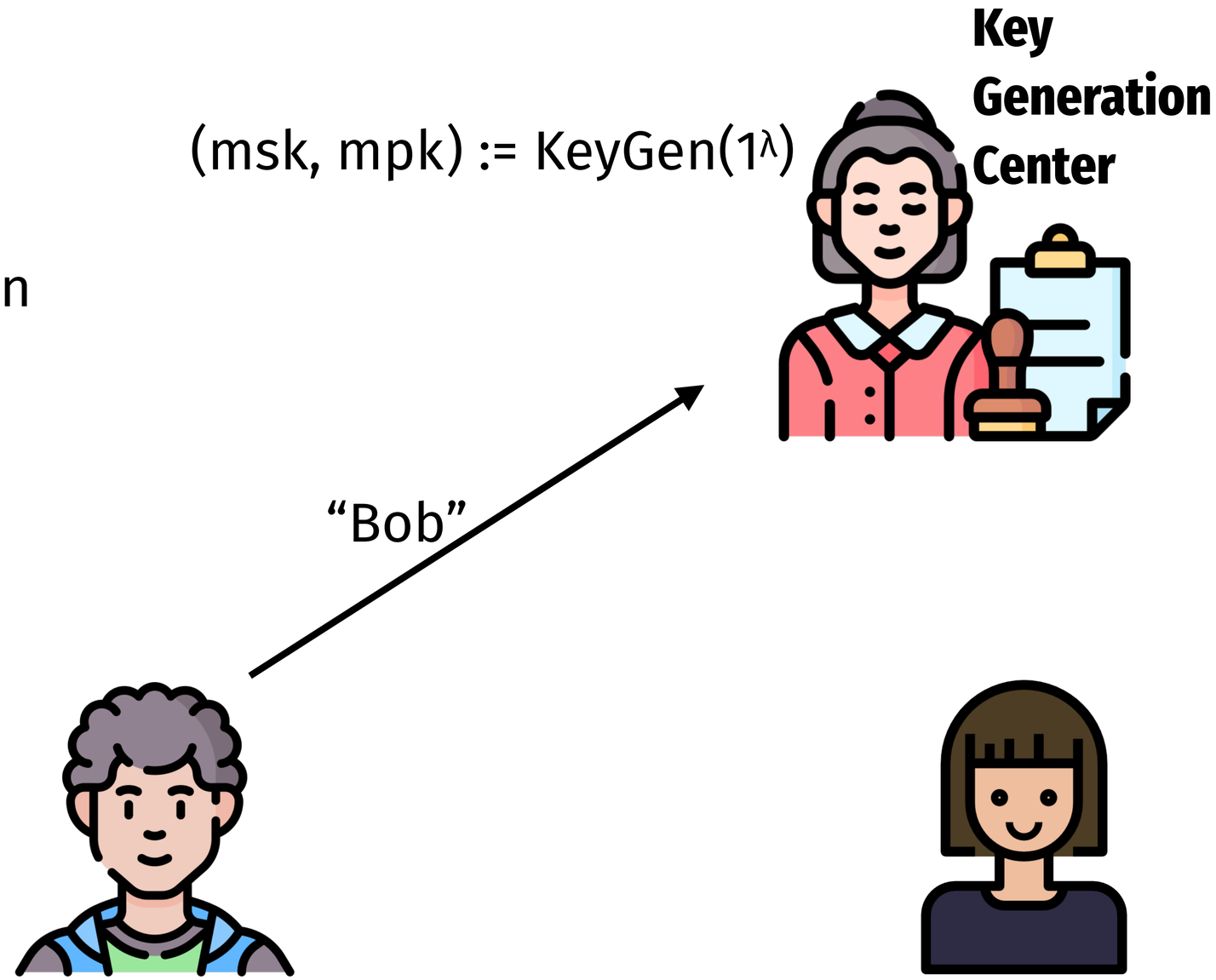

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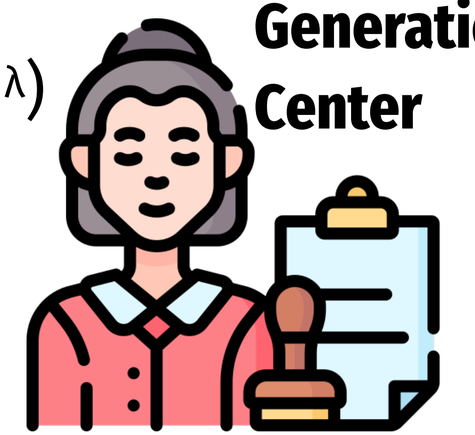

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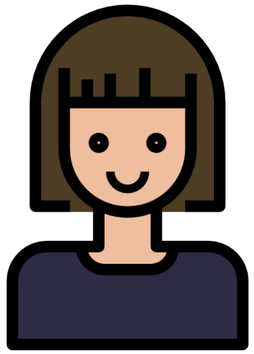

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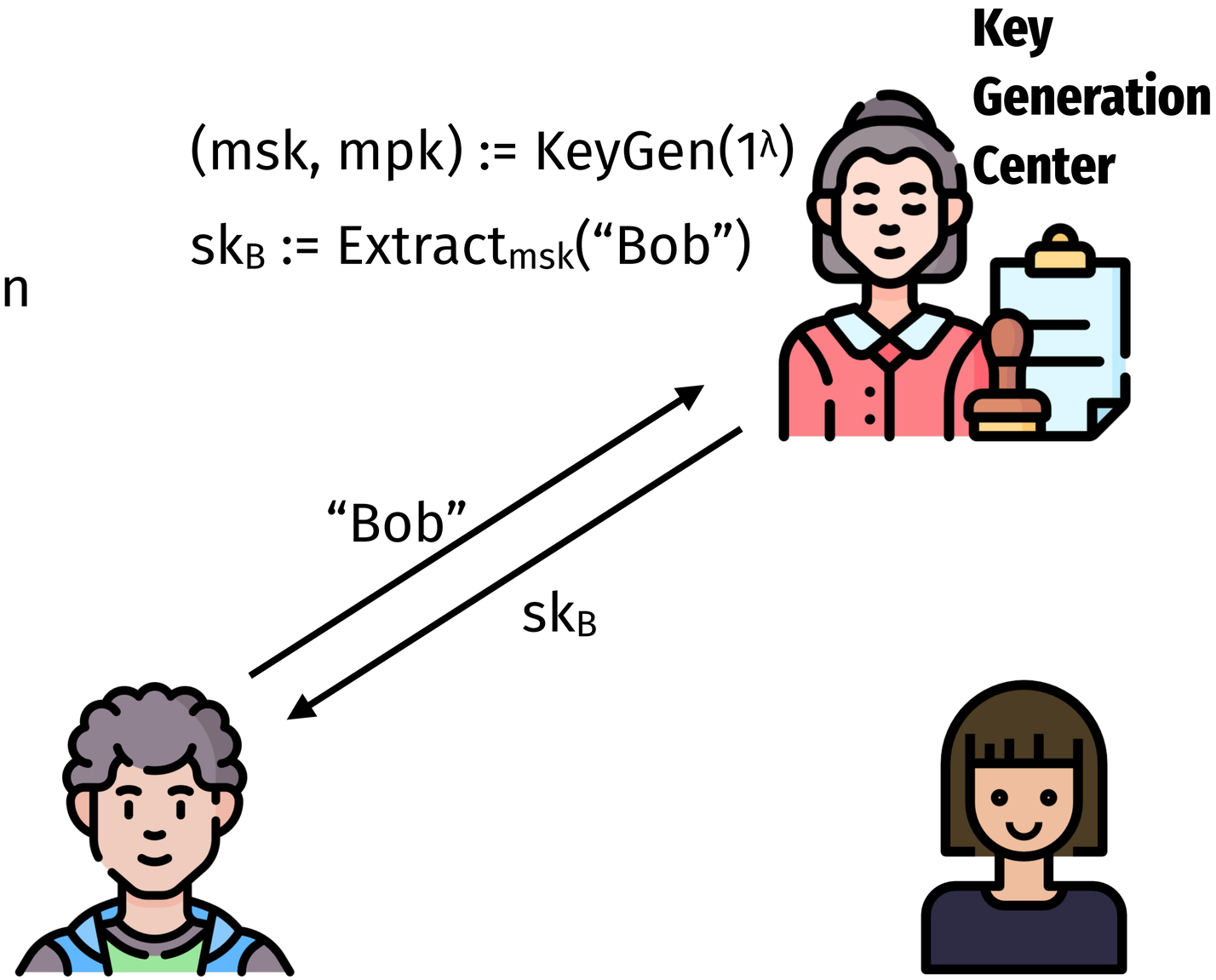

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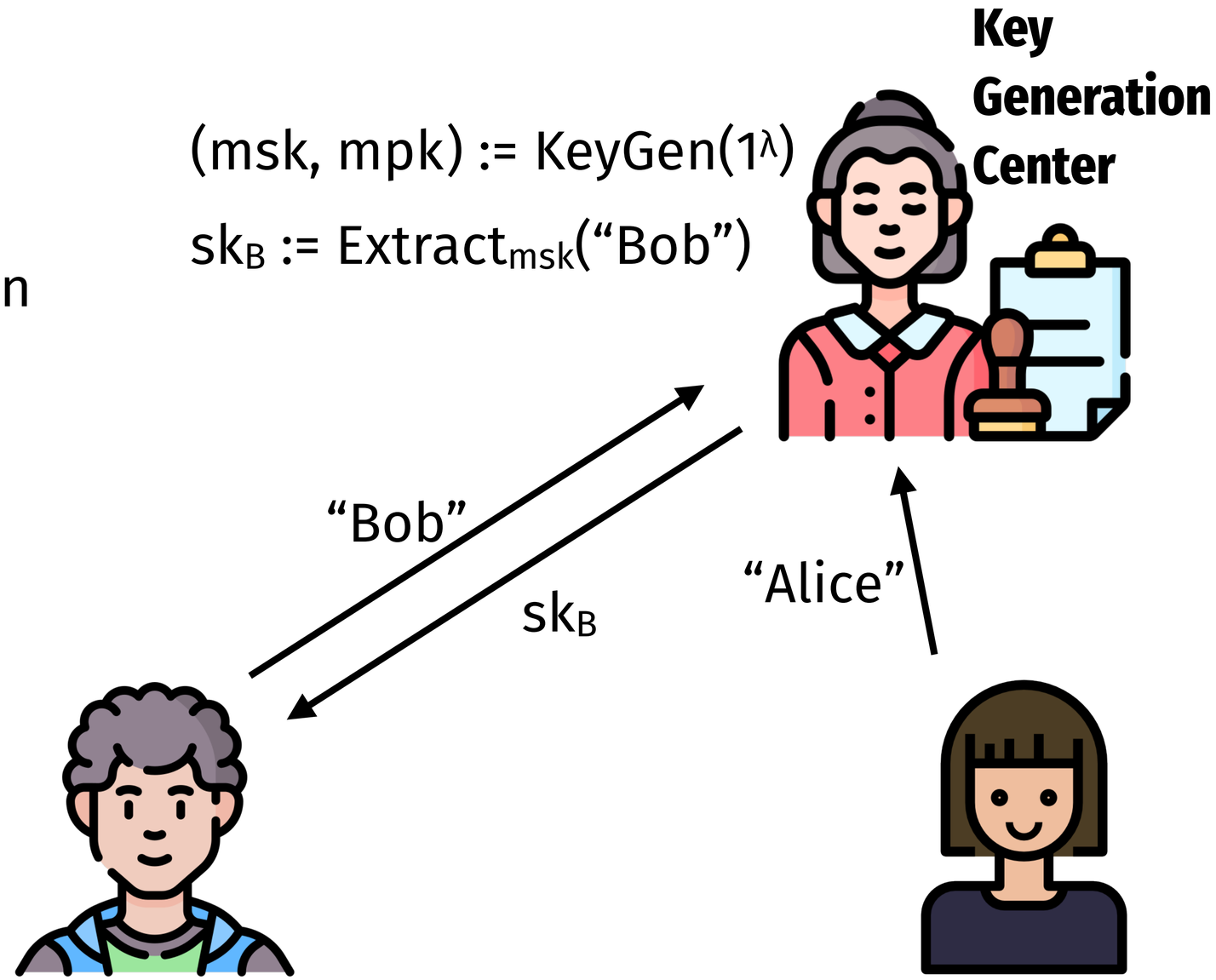

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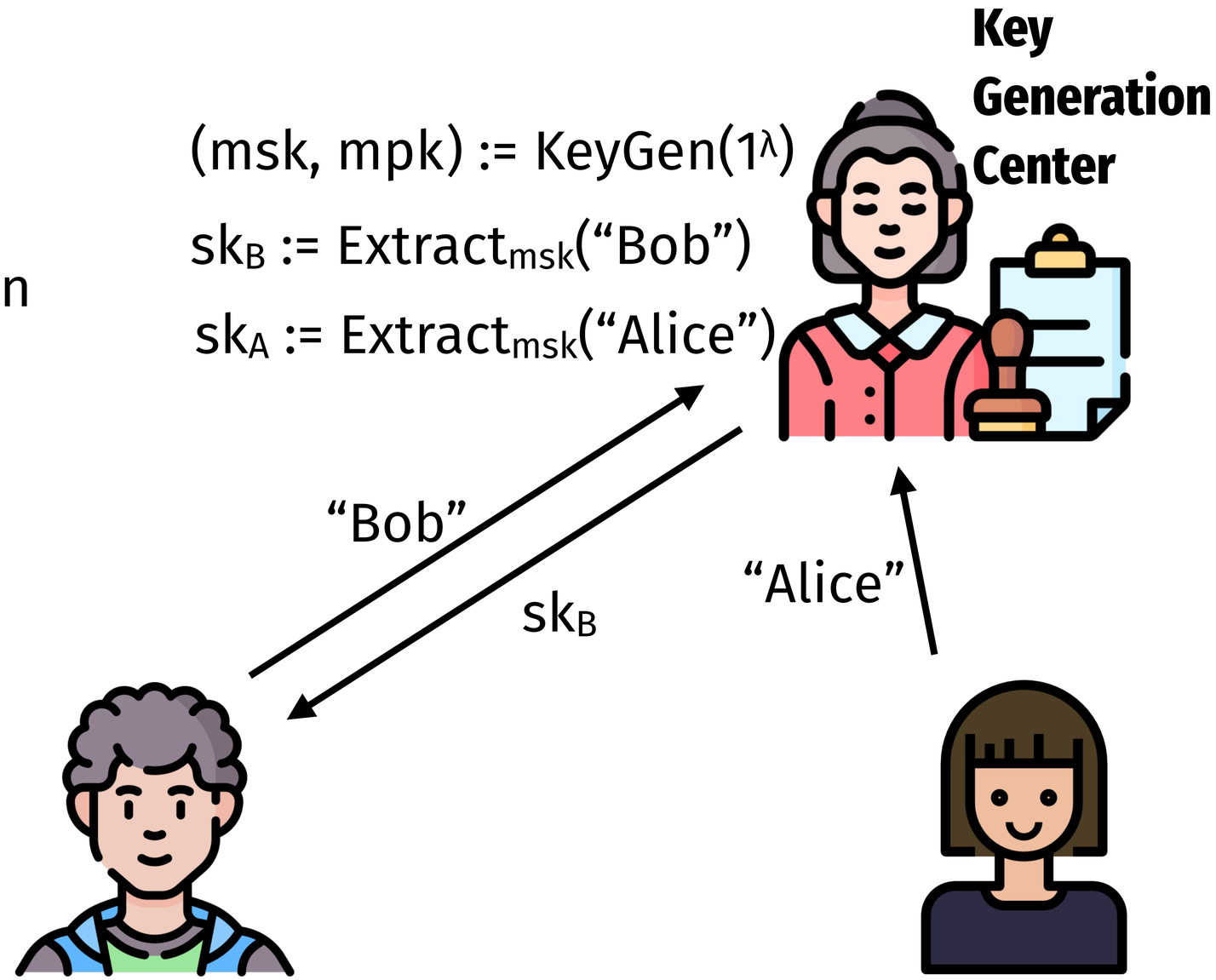

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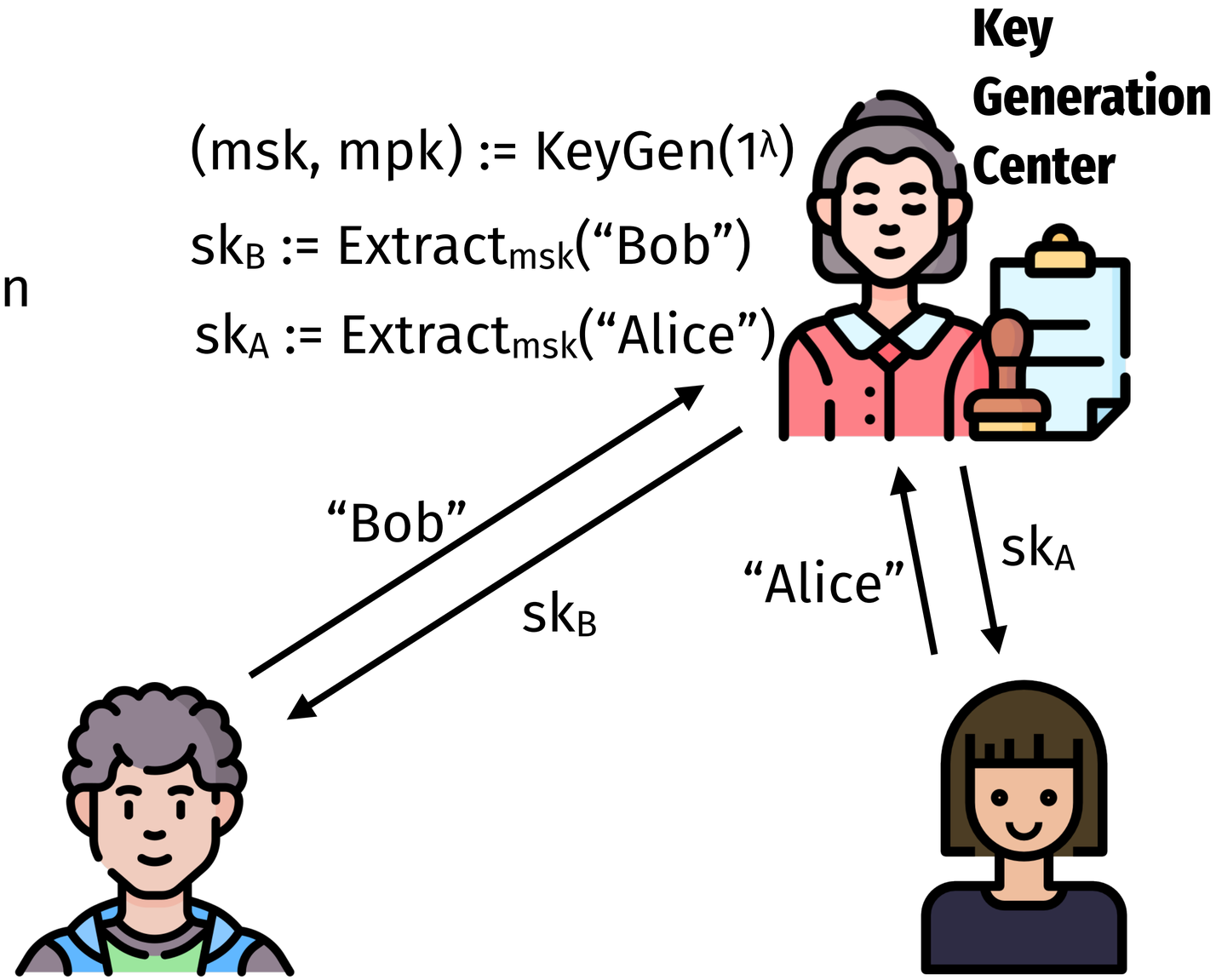

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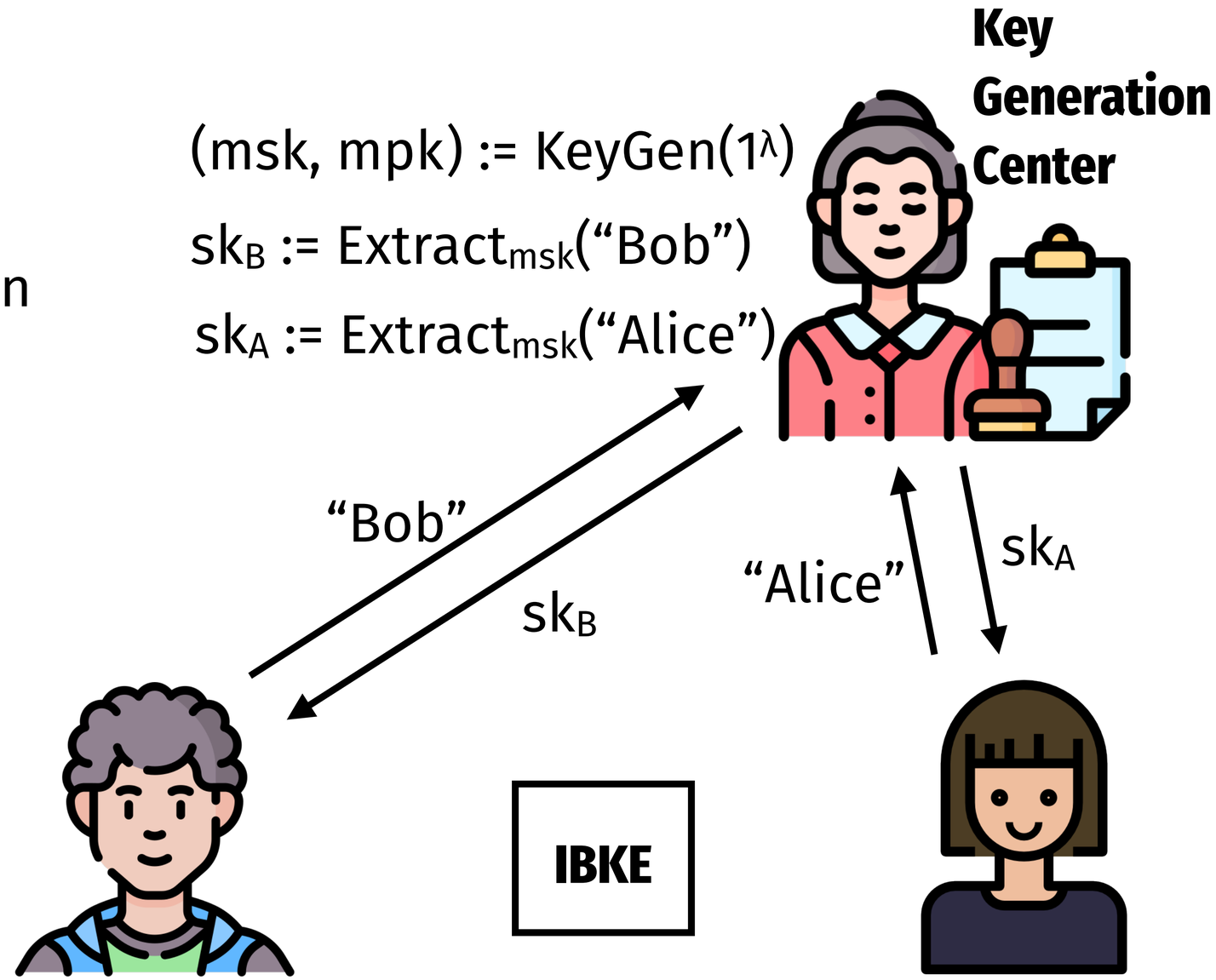

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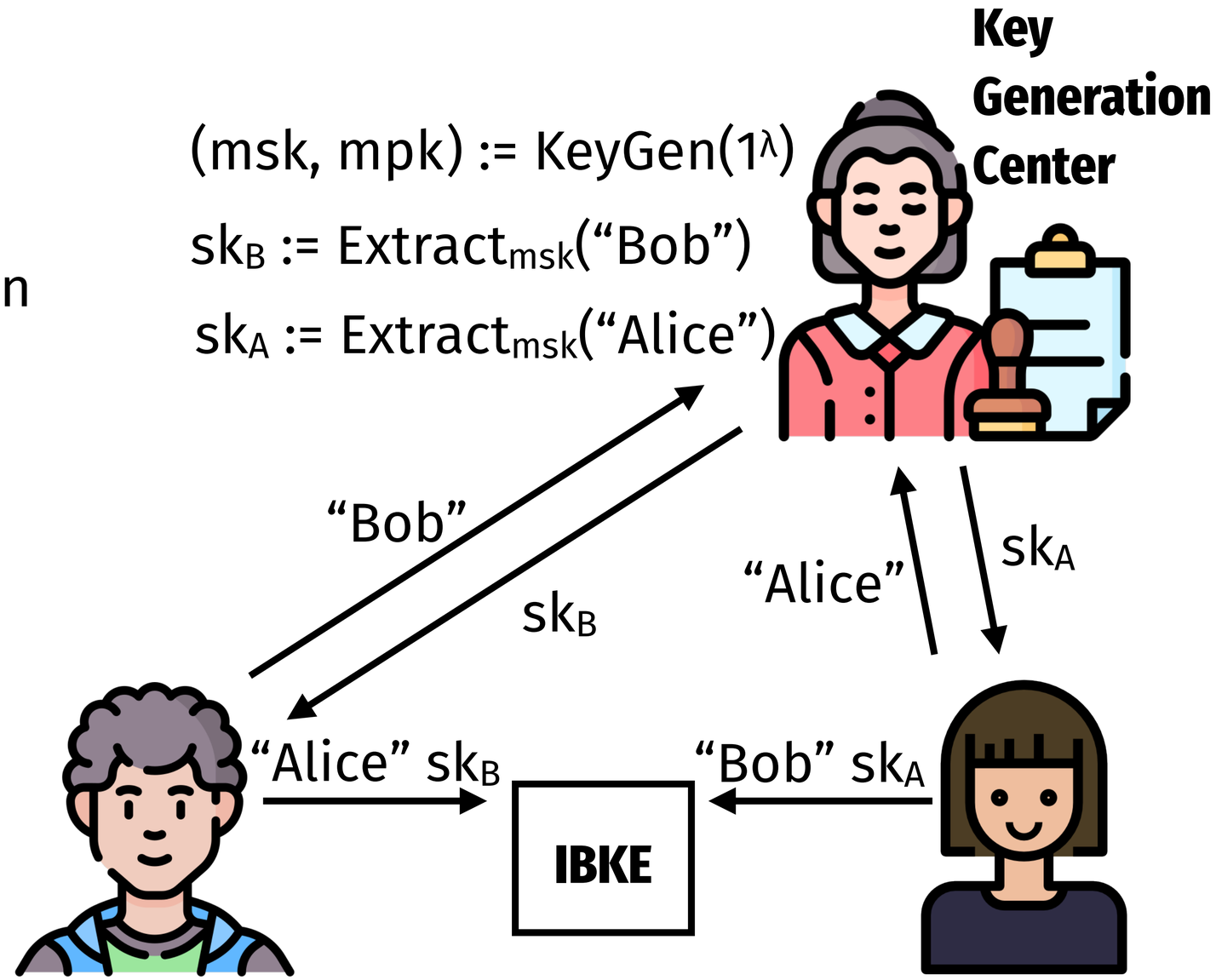

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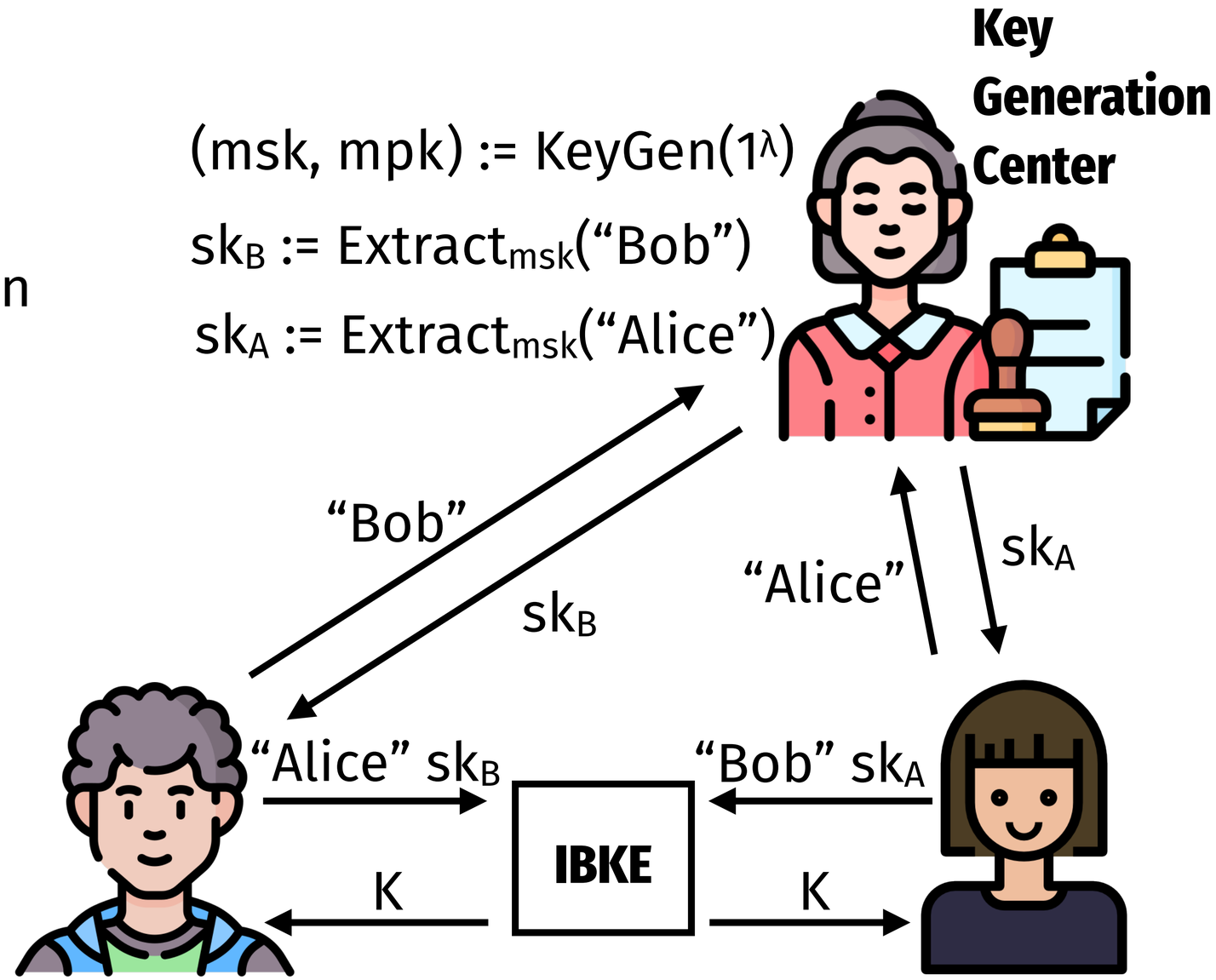

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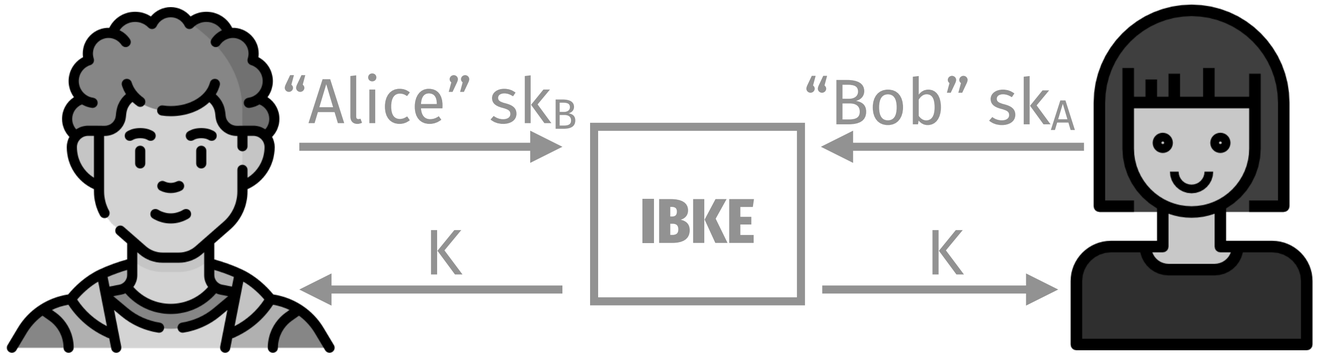

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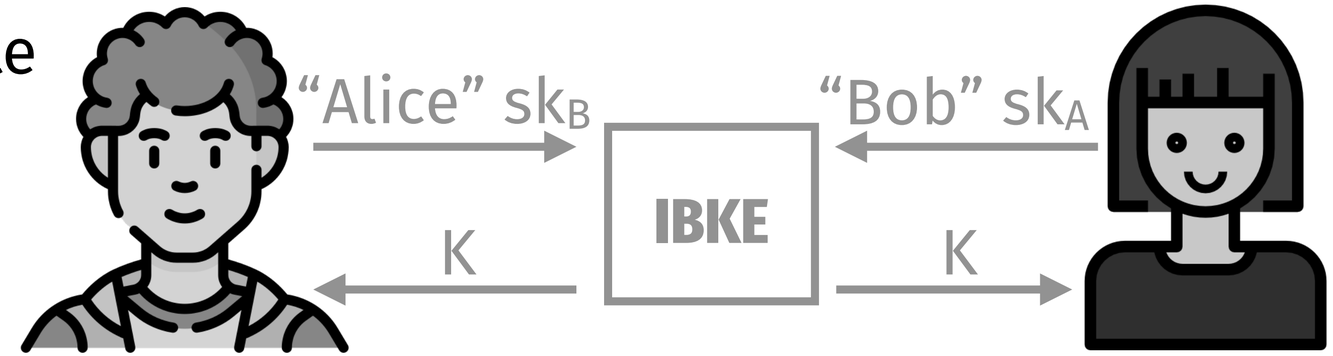

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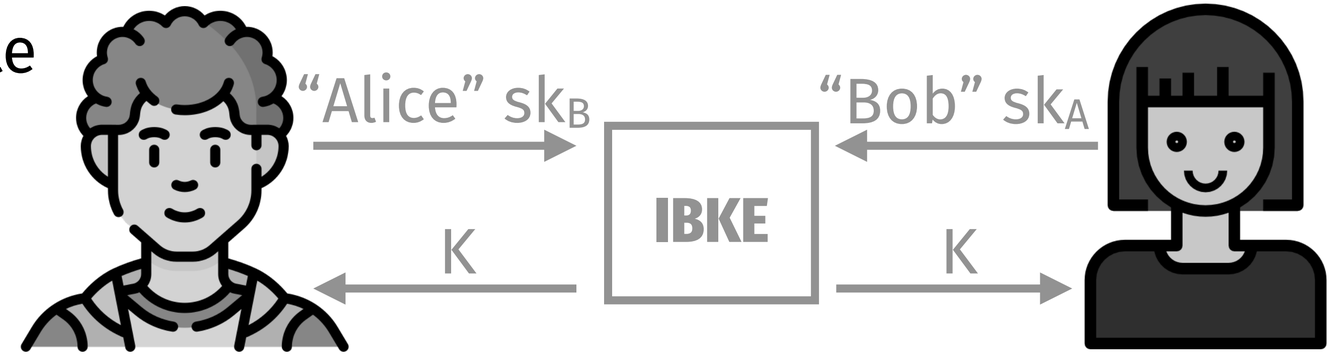

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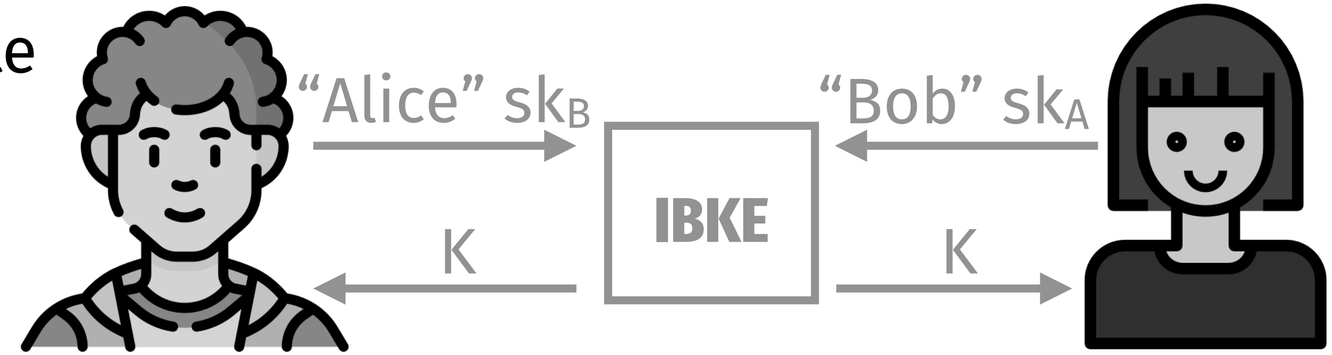

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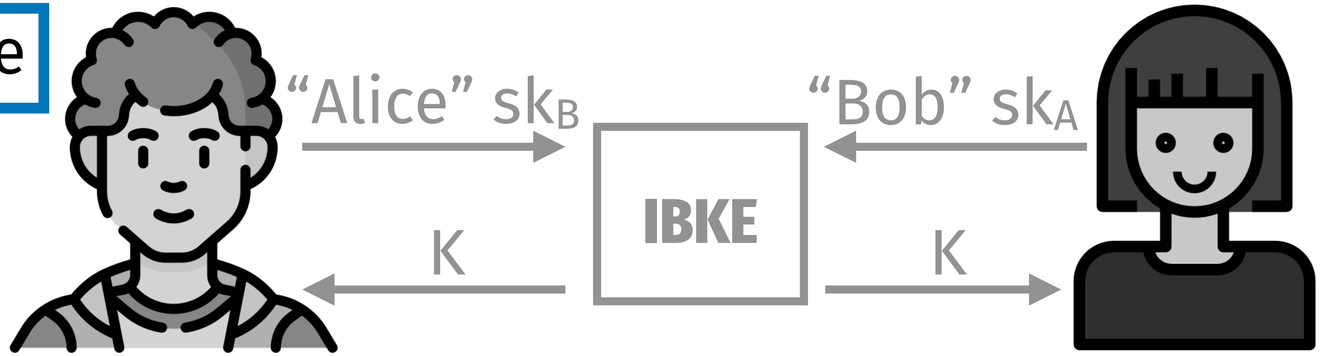

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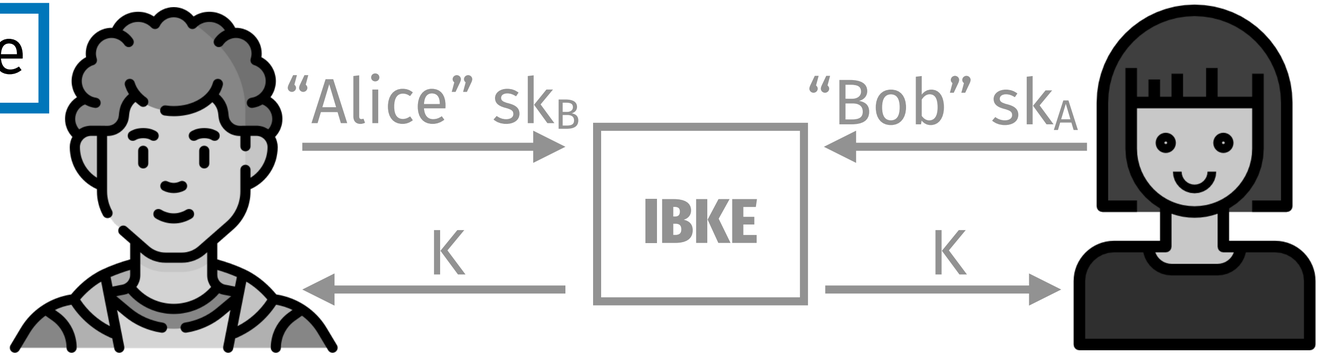

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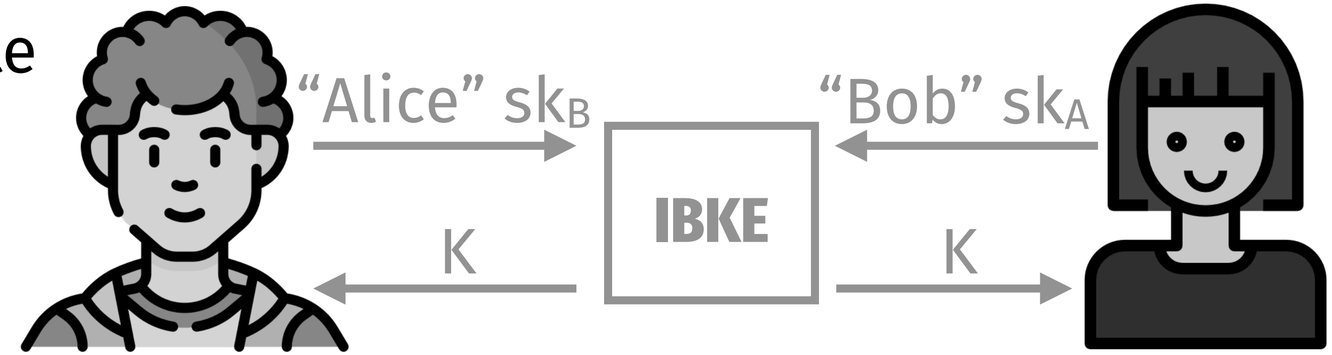

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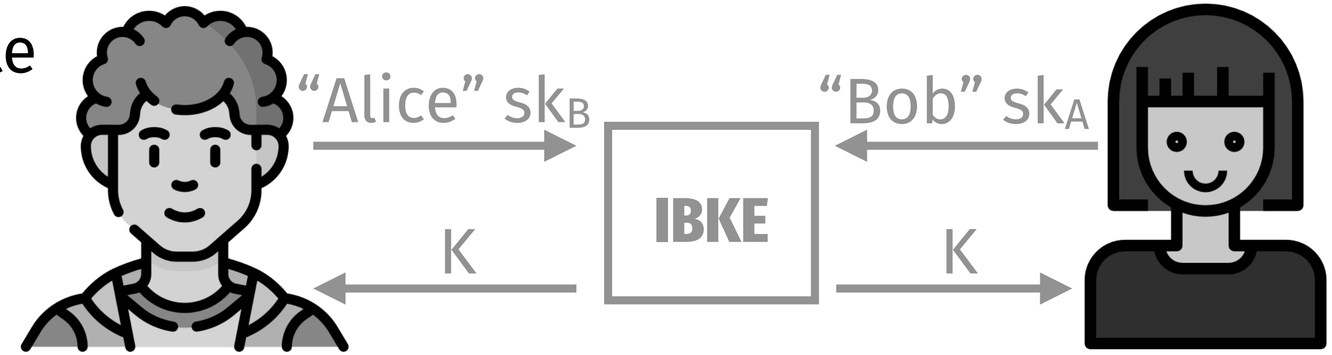

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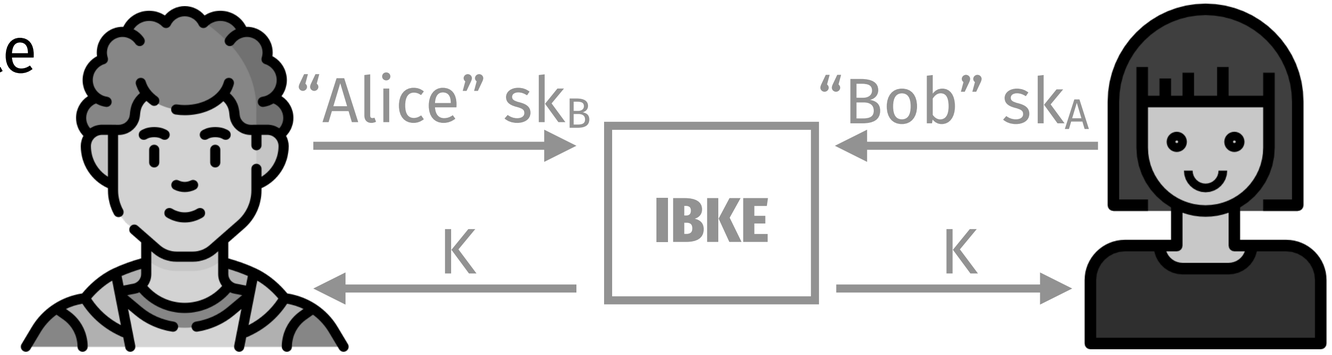

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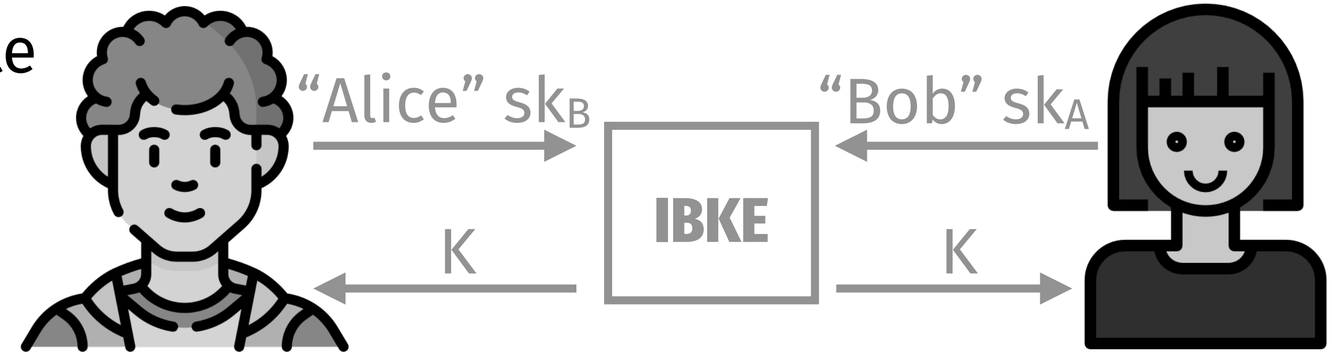

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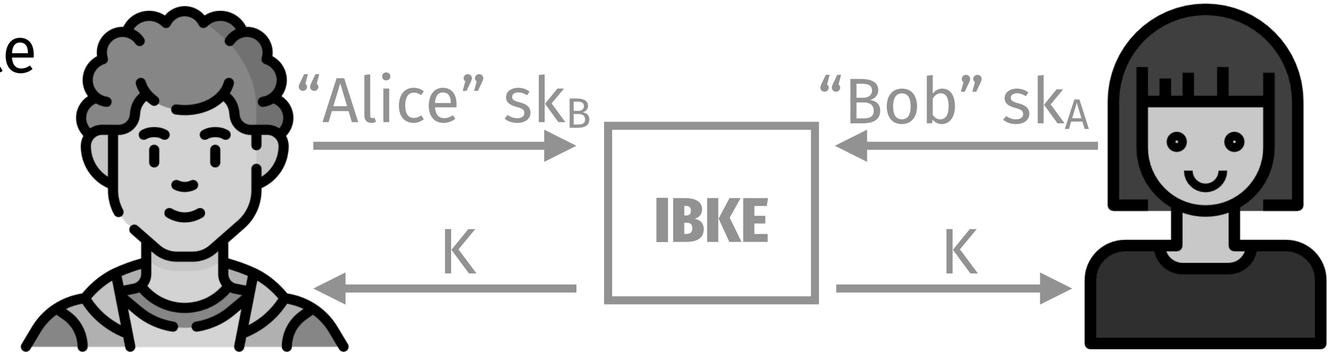

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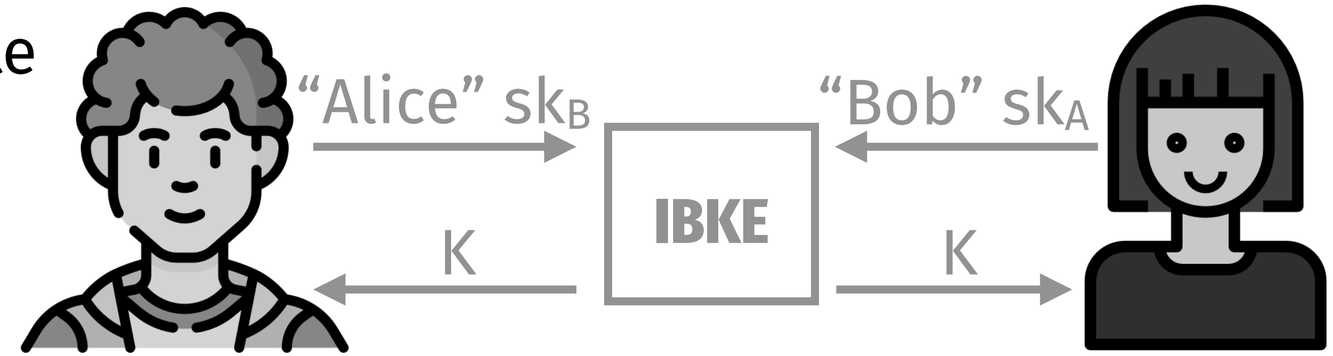

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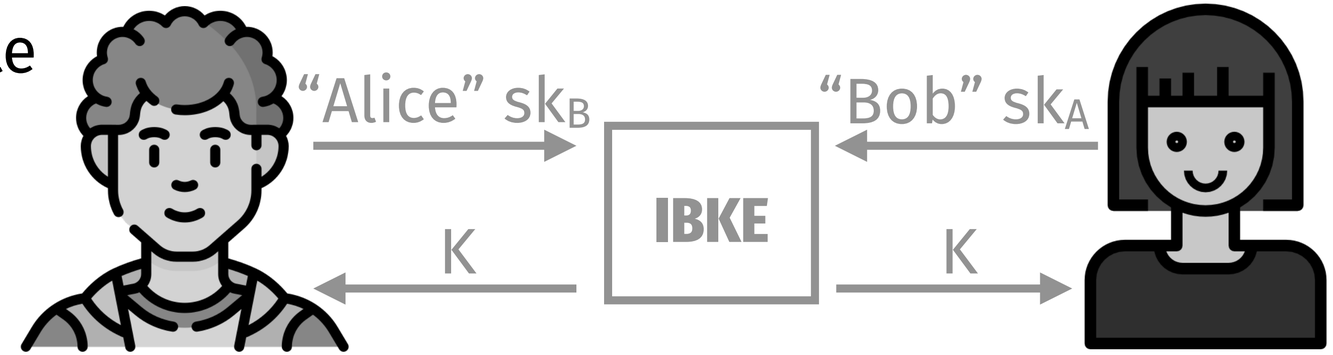

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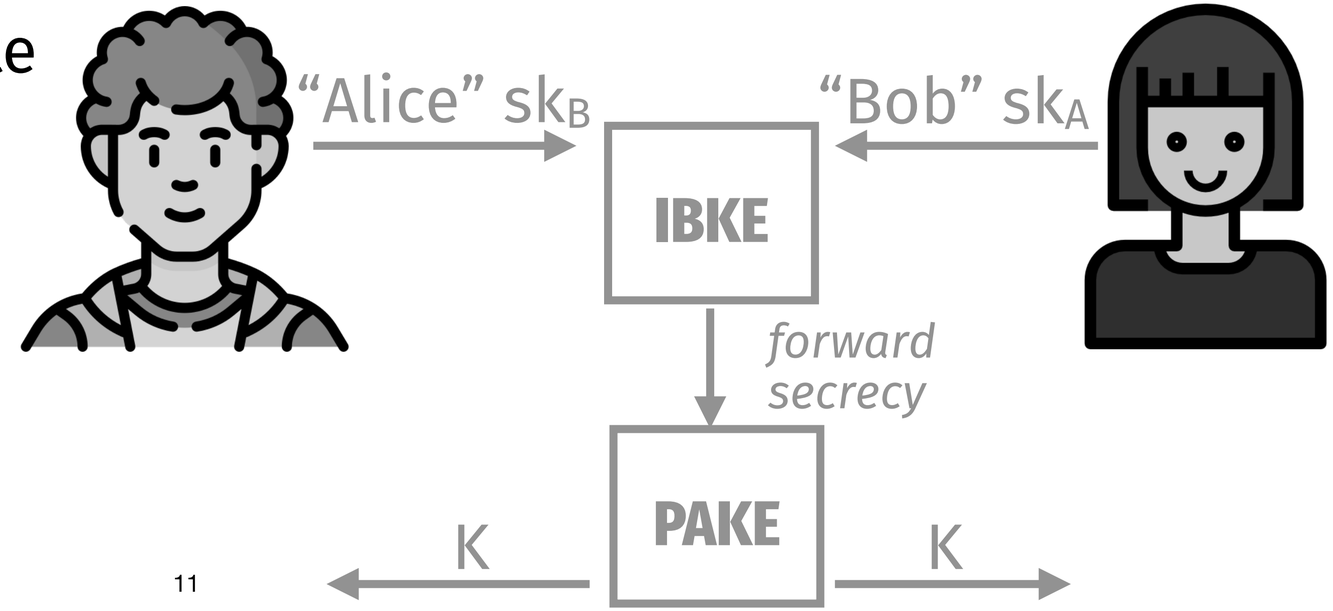

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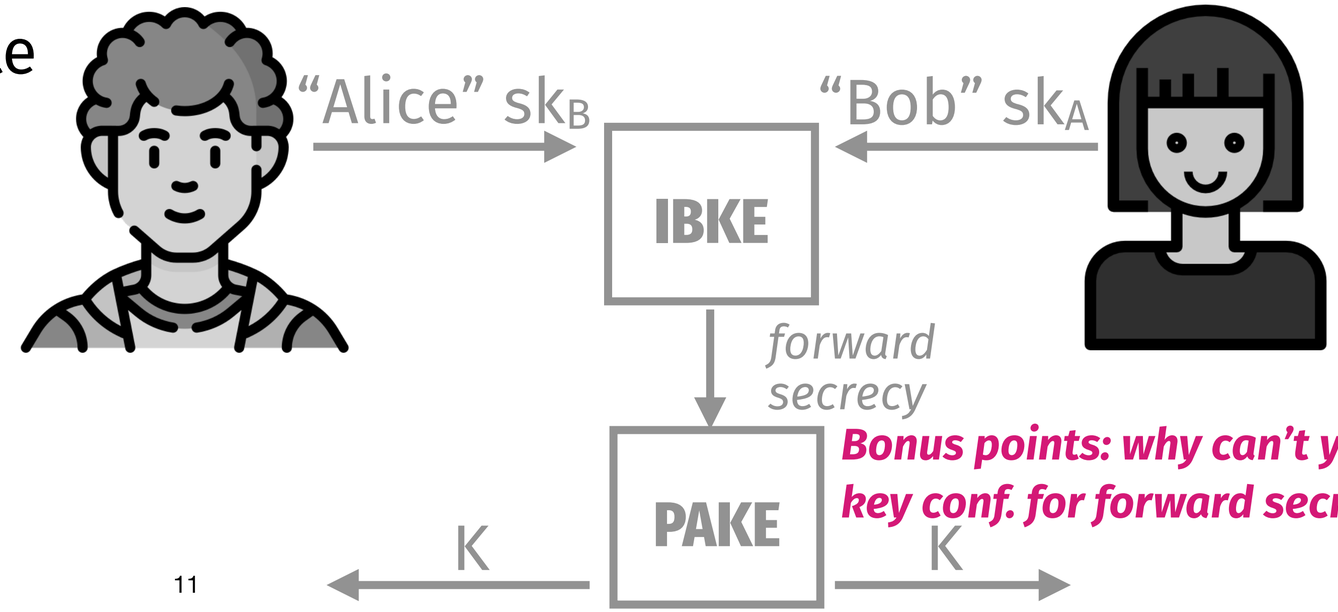

Bonus points: why can't you use key conf. for forward secrecy?

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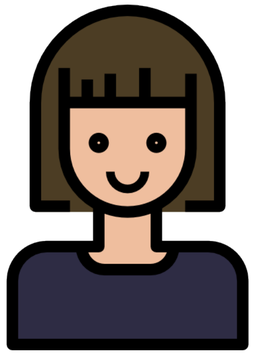

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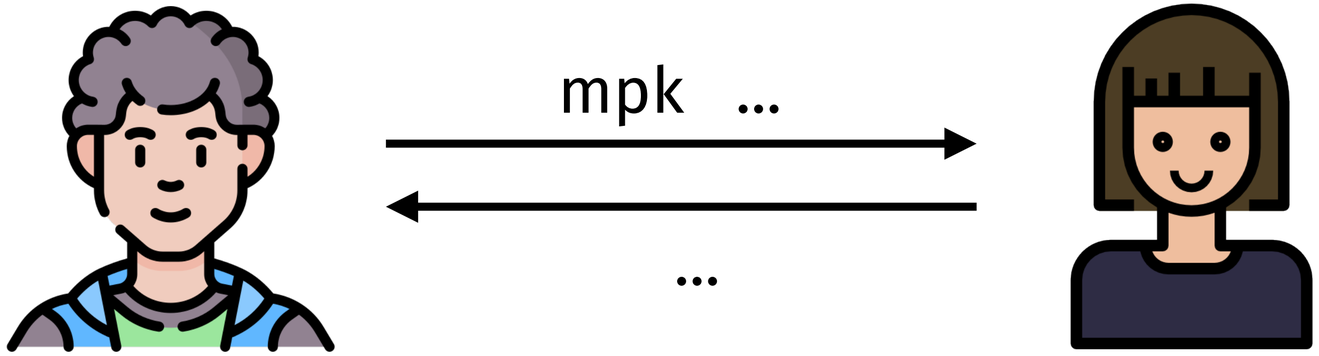

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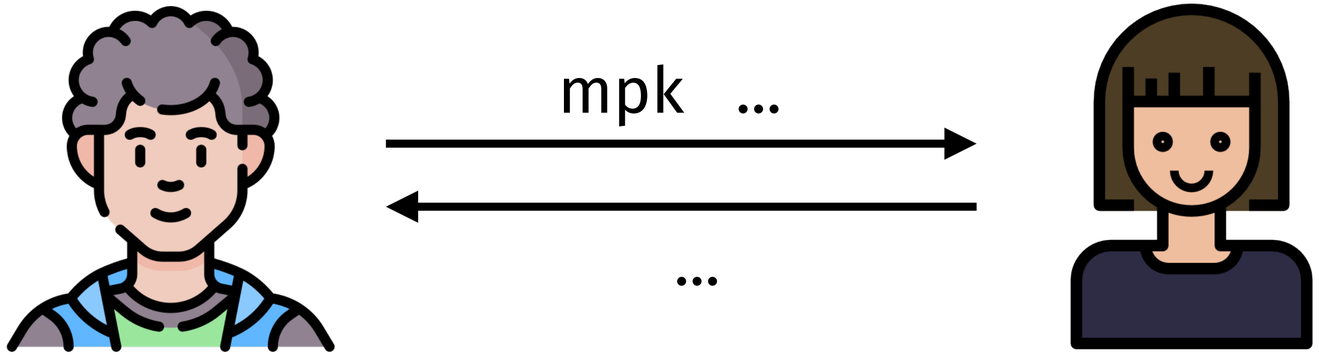

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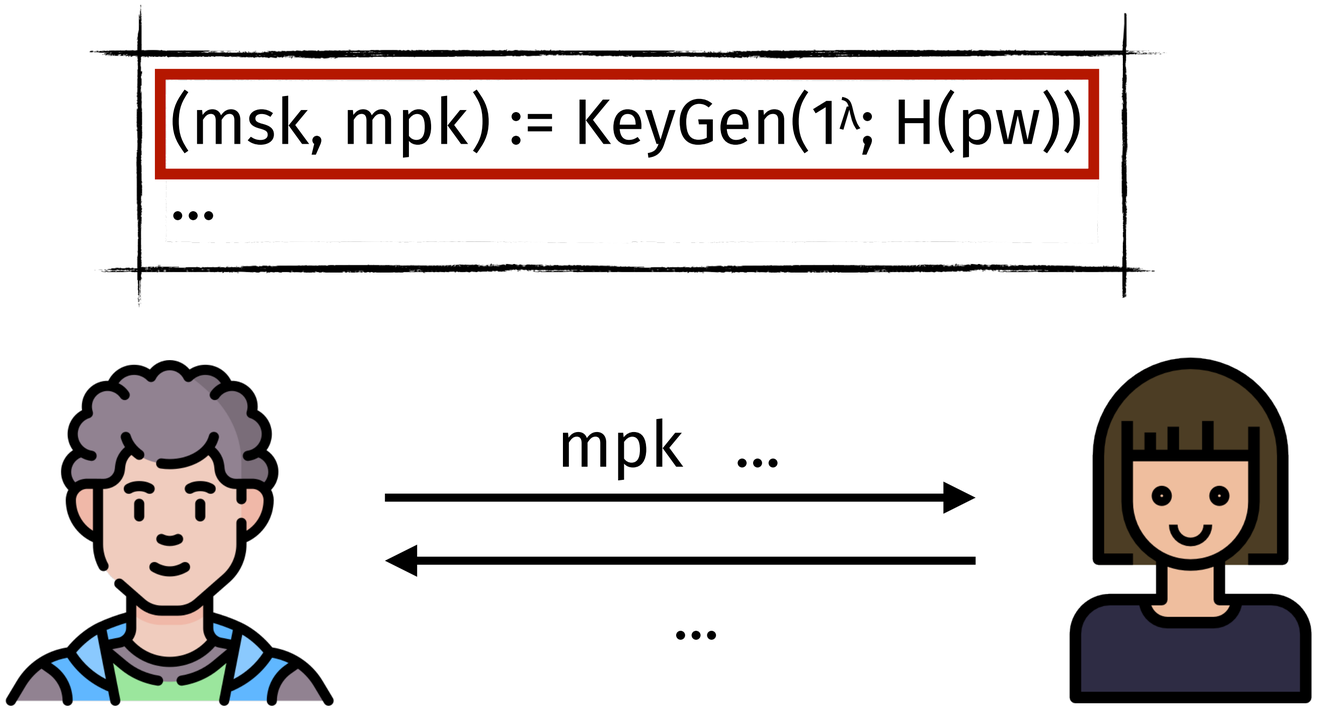

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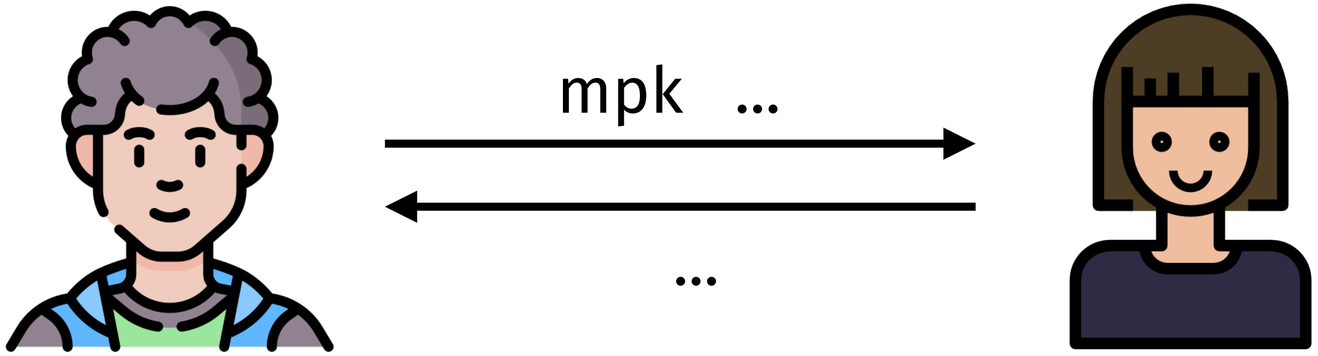

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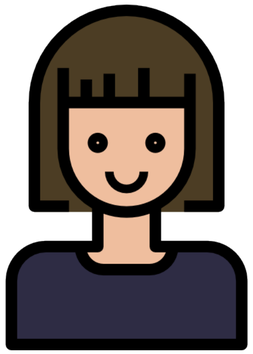

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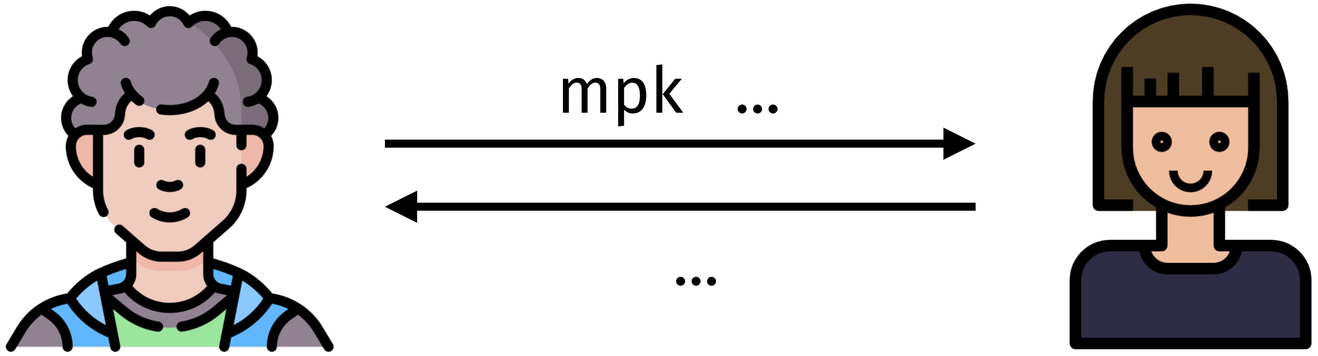

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⇒ No route to make CHIP (or CRISP) post-quantum

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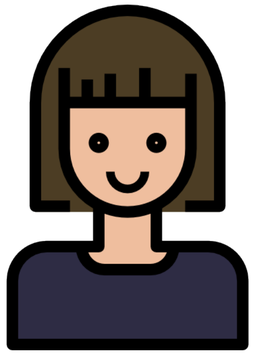

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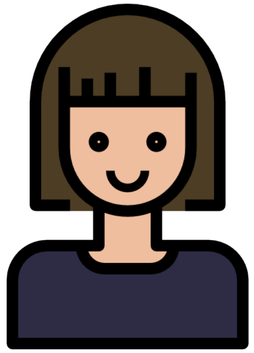

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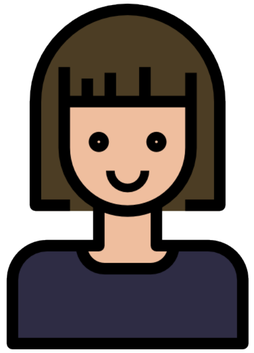

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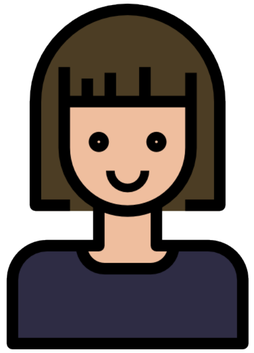

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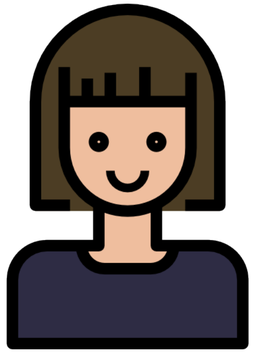

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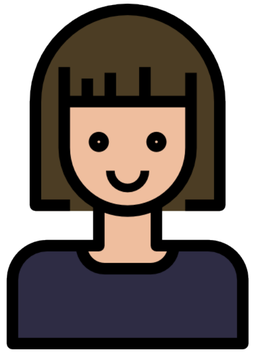

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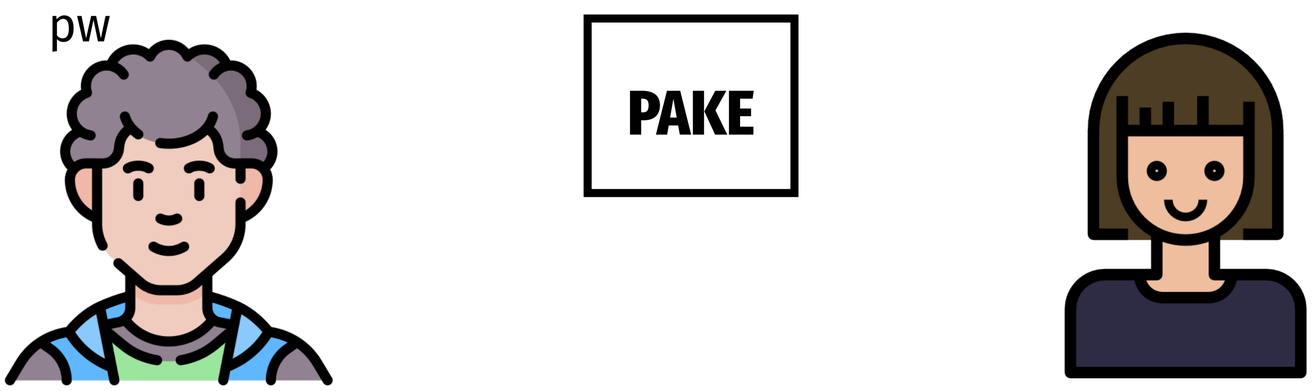

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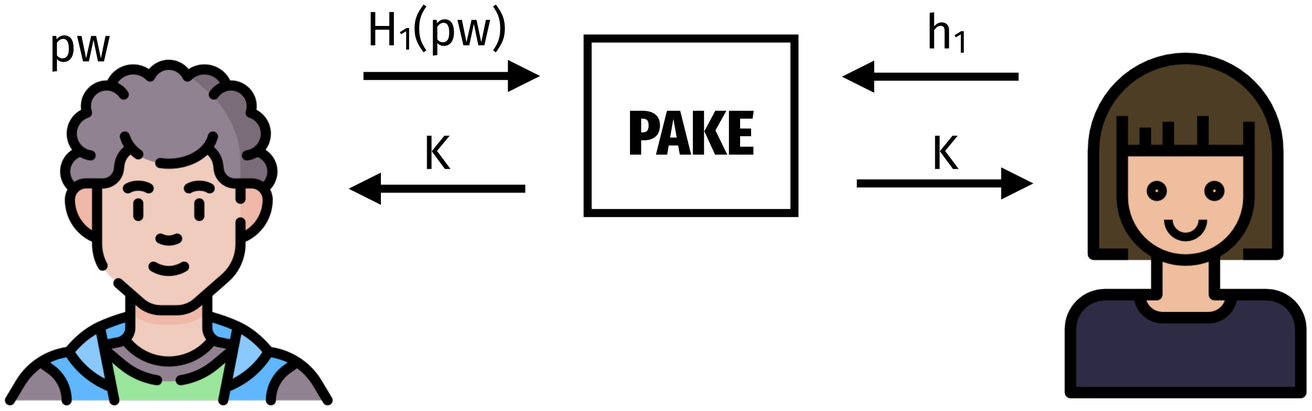

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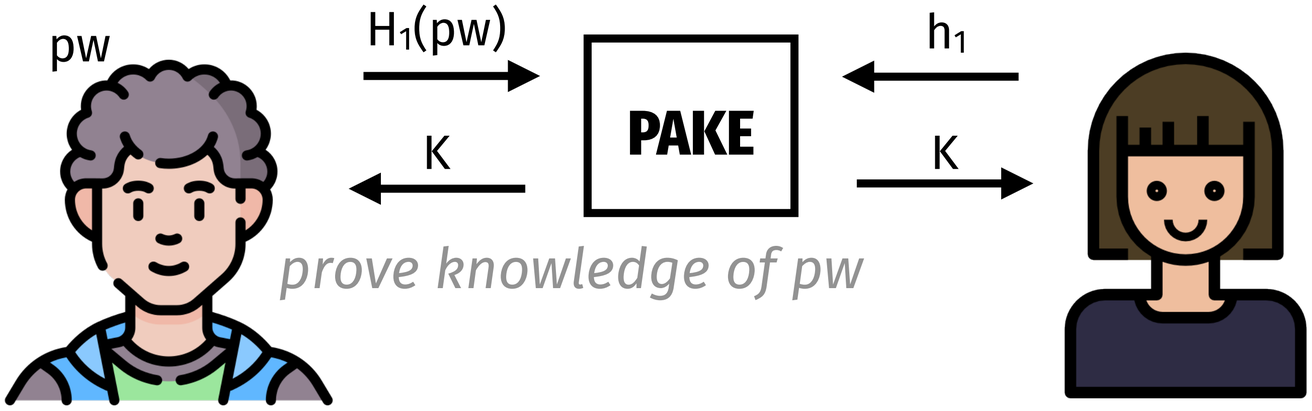

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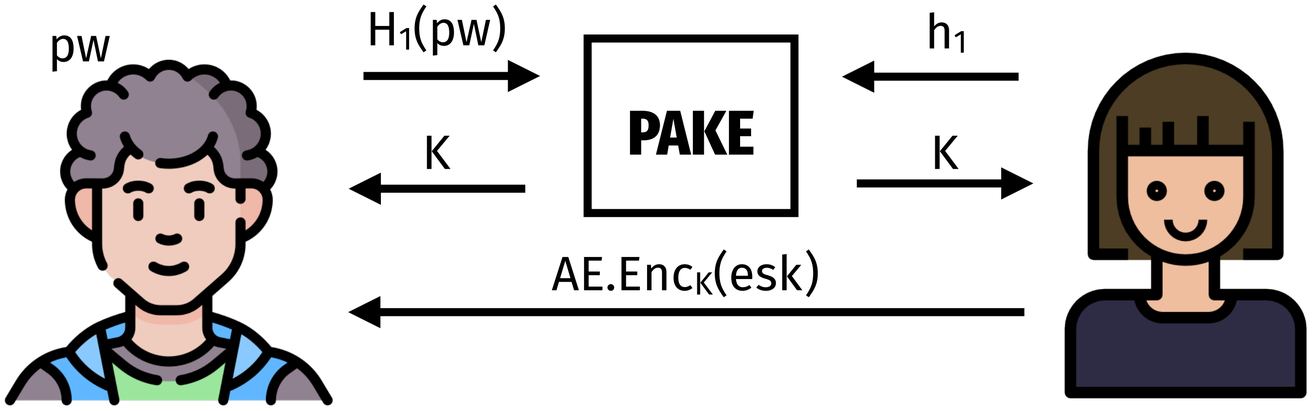

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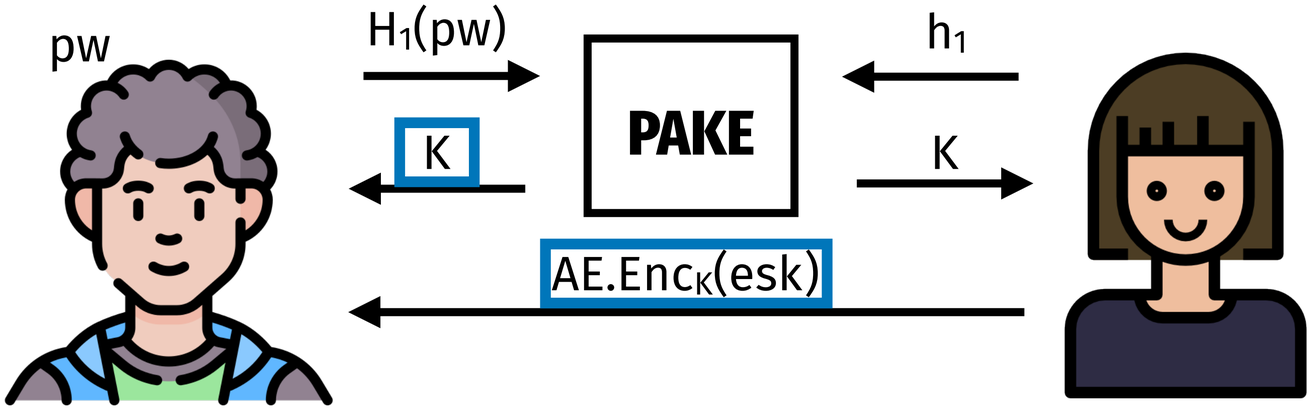

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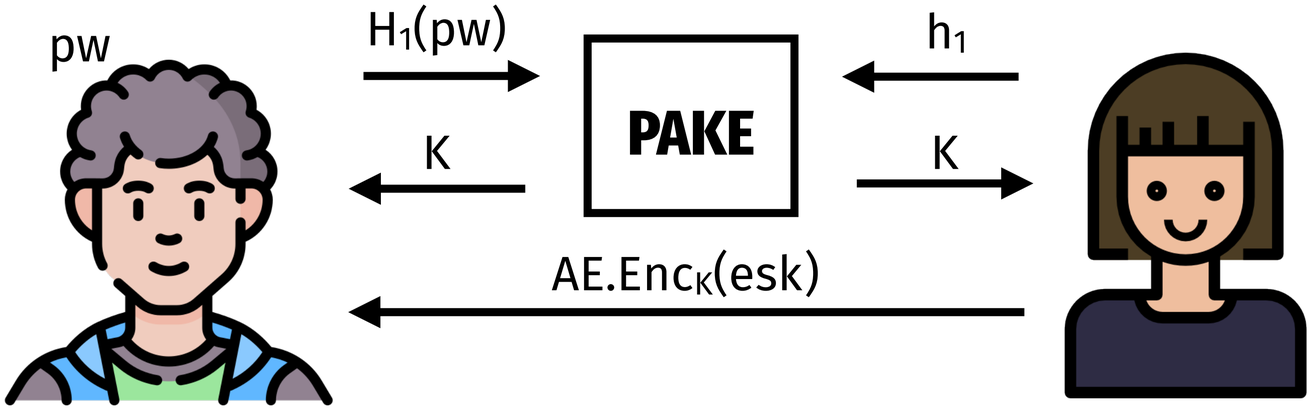

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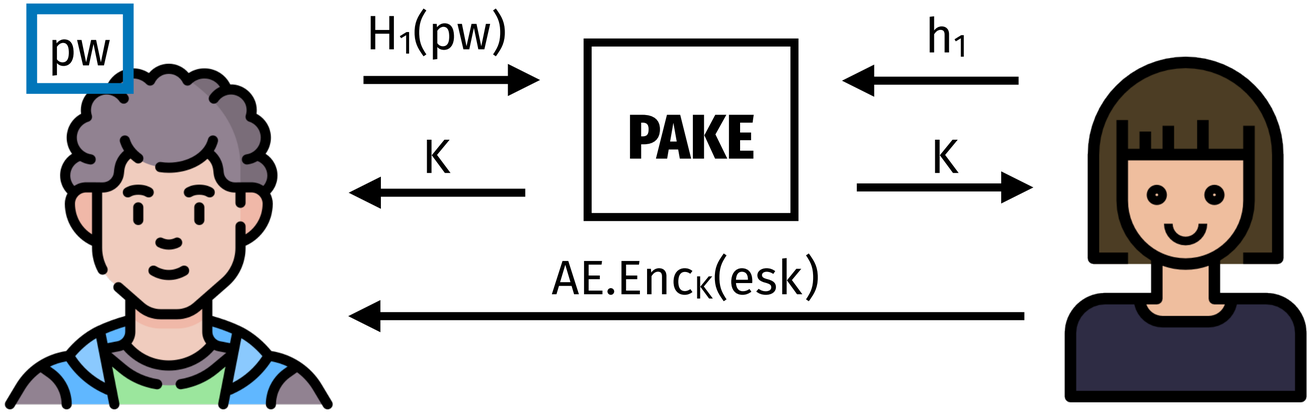

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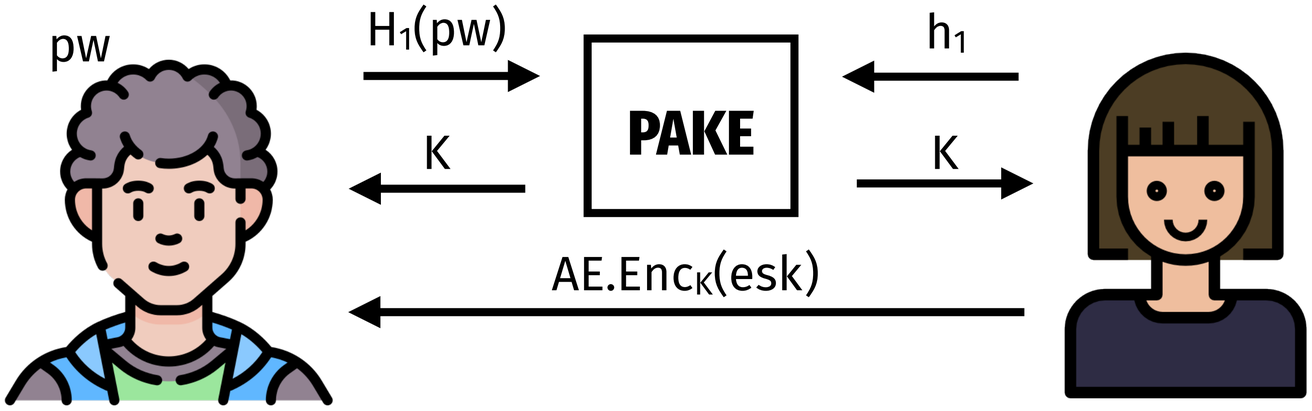

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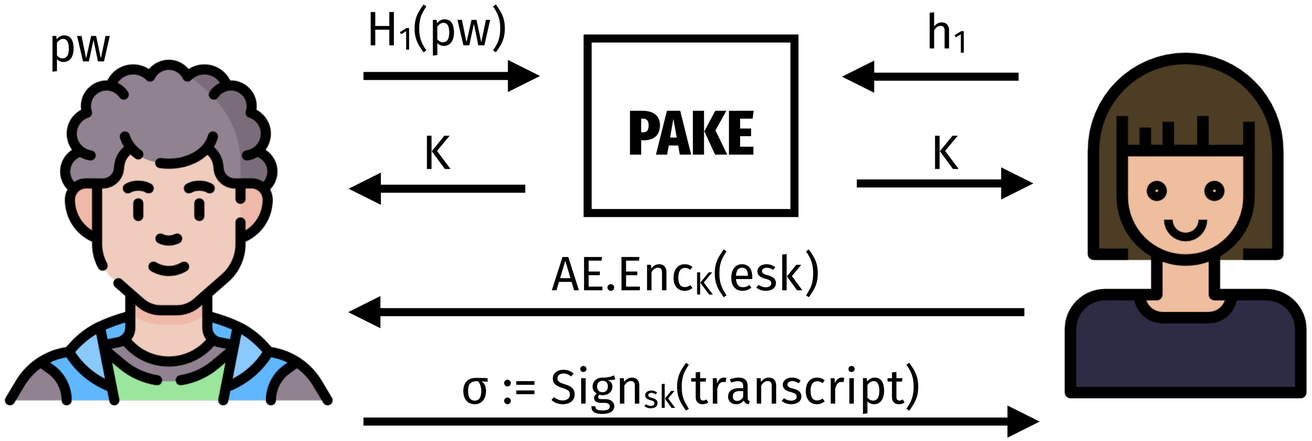

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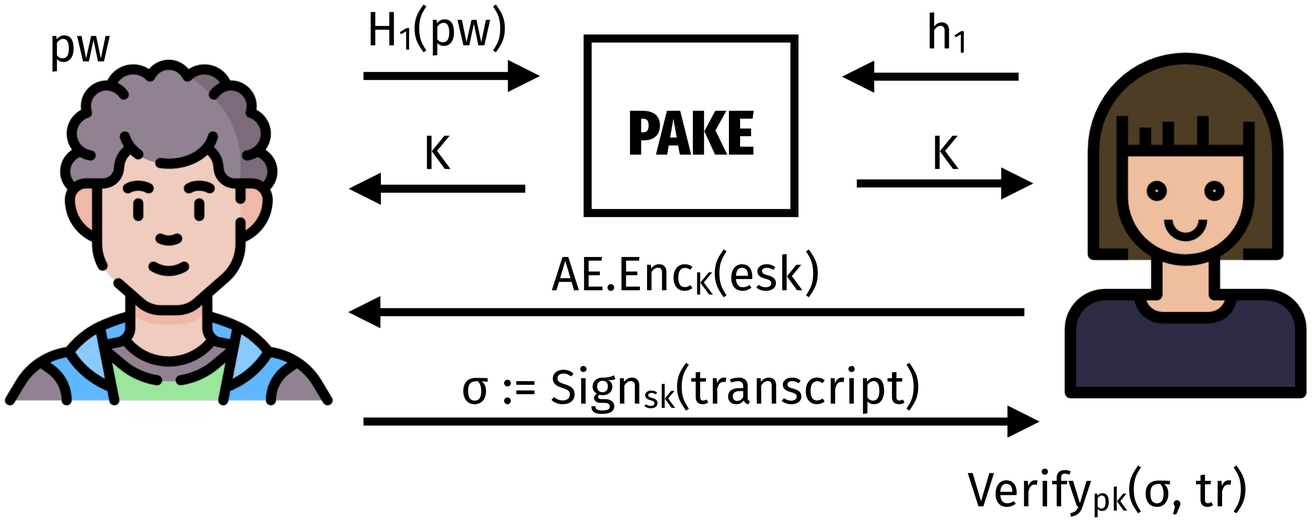

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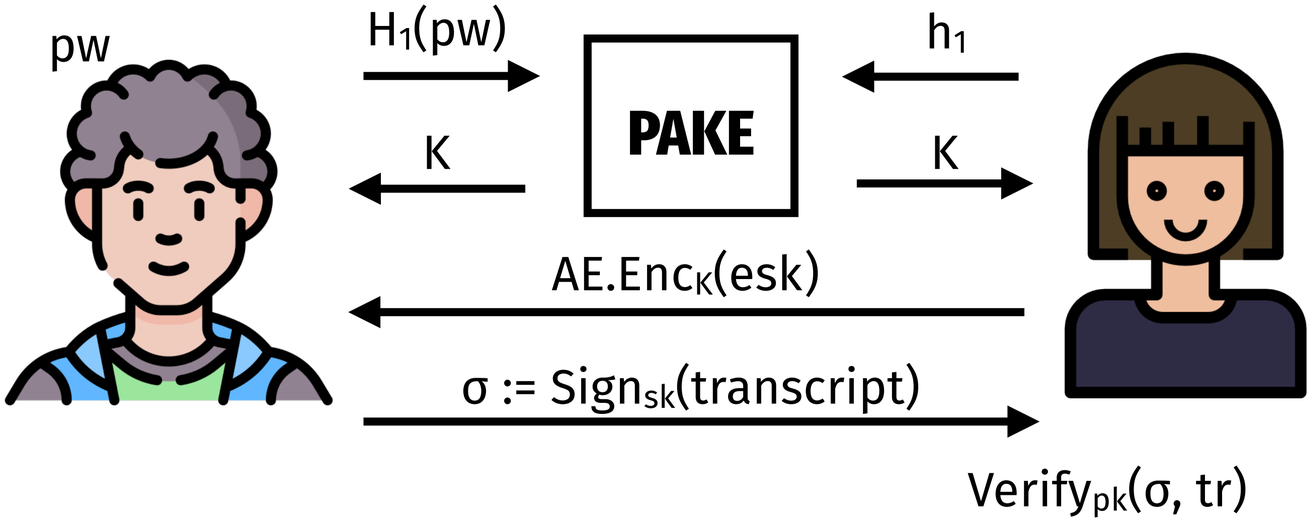

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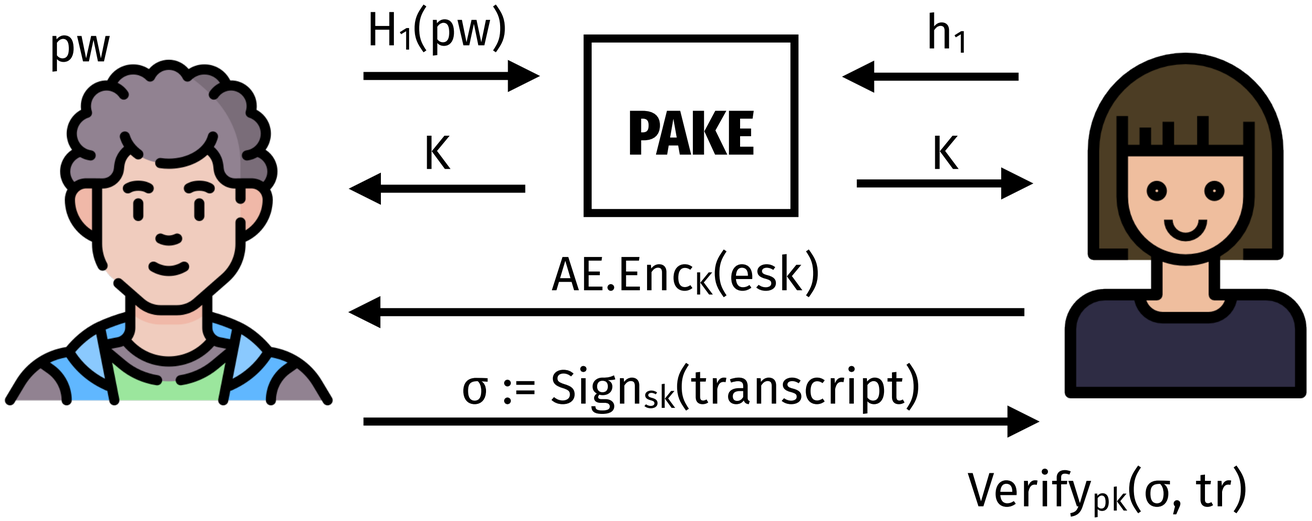

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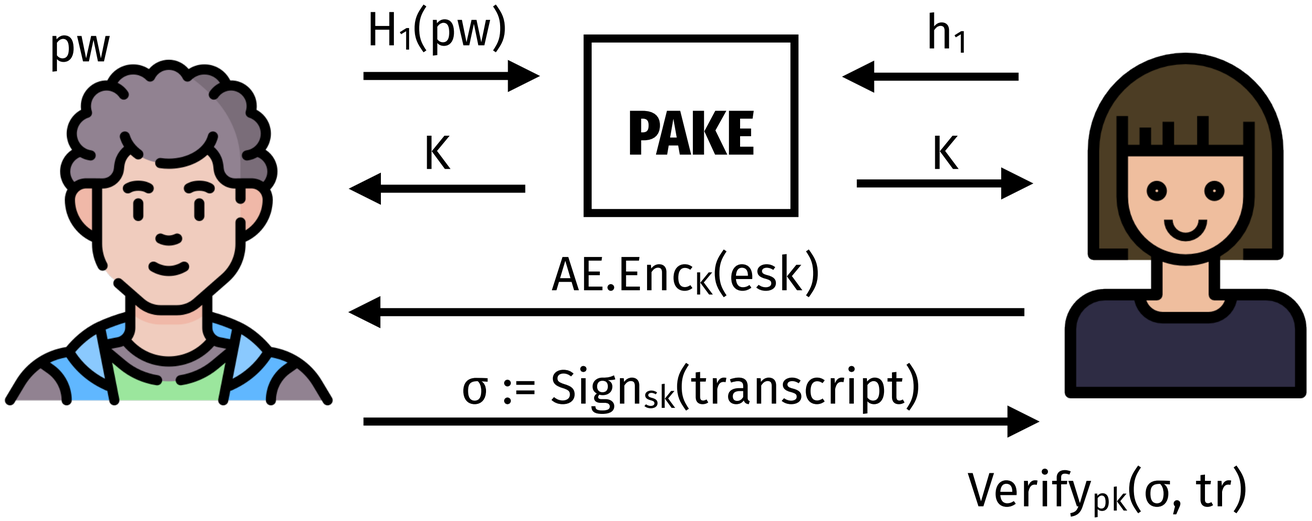

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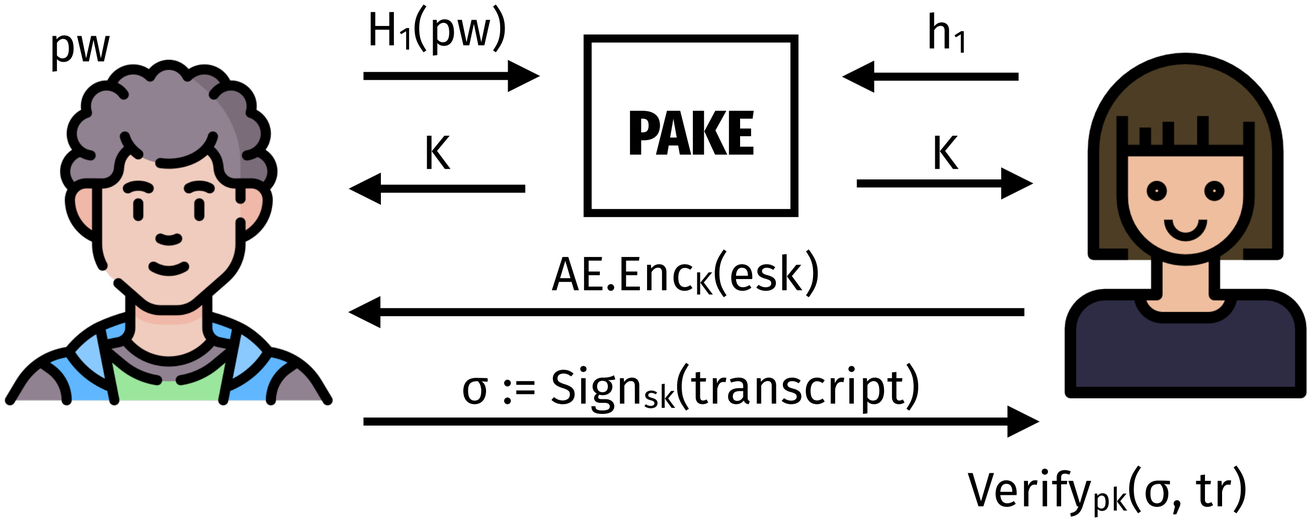

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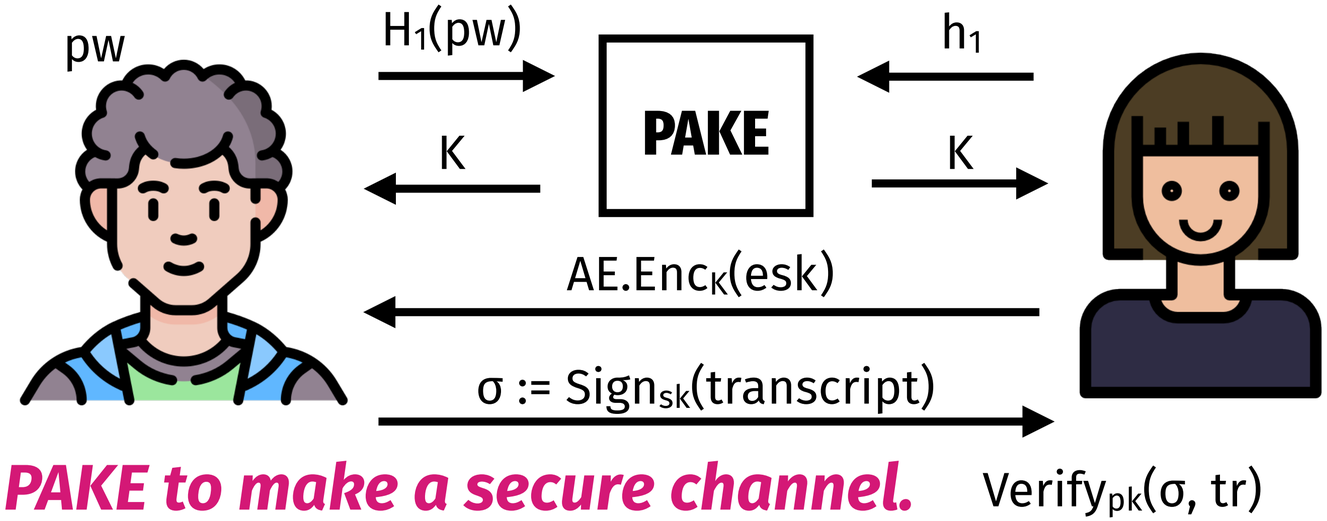
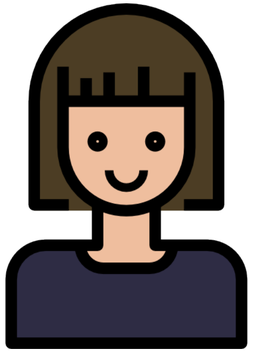


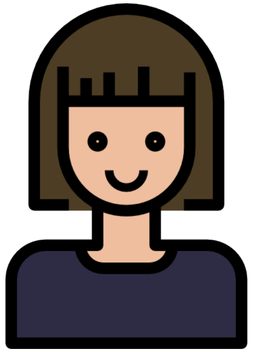
Takeaway: use a PAKE to make a secure channel. Then put leaky protocols in that channel

LATKE Construction



LATKE Construction

Use **self-KGC trick** of CHIP



LATKE Construction

Use **self-KGC trick** of CHIP

LATKE.Setup(pw, id) *same as CHIP*

$(msk, mpk) := KeyGen(1^\lambda; H(pw))$

$sk_{id} := Extract_{msk}(id)$

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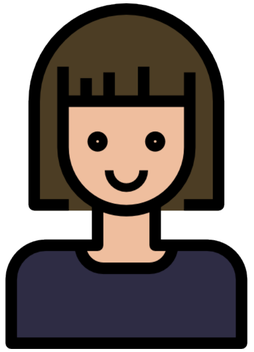

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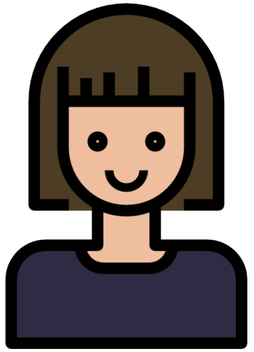

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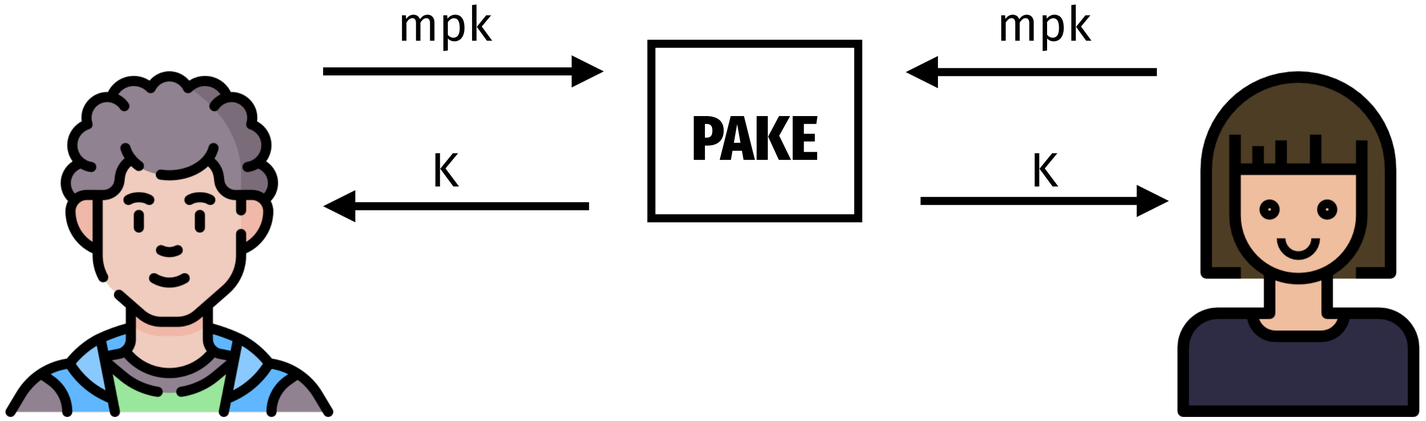

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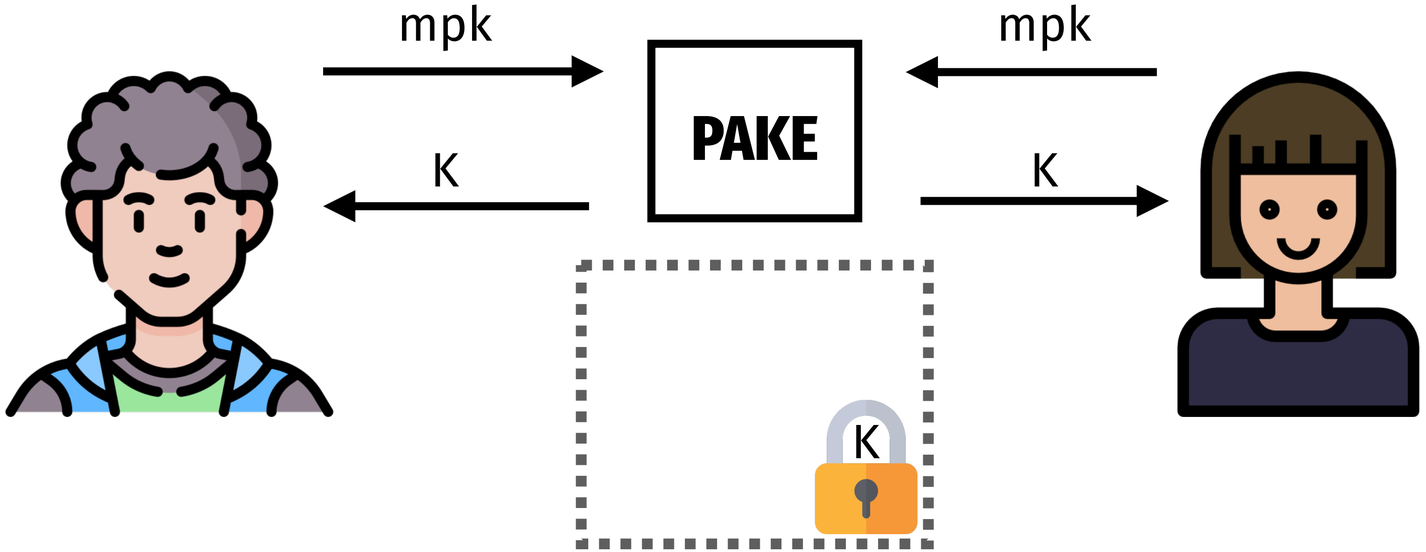

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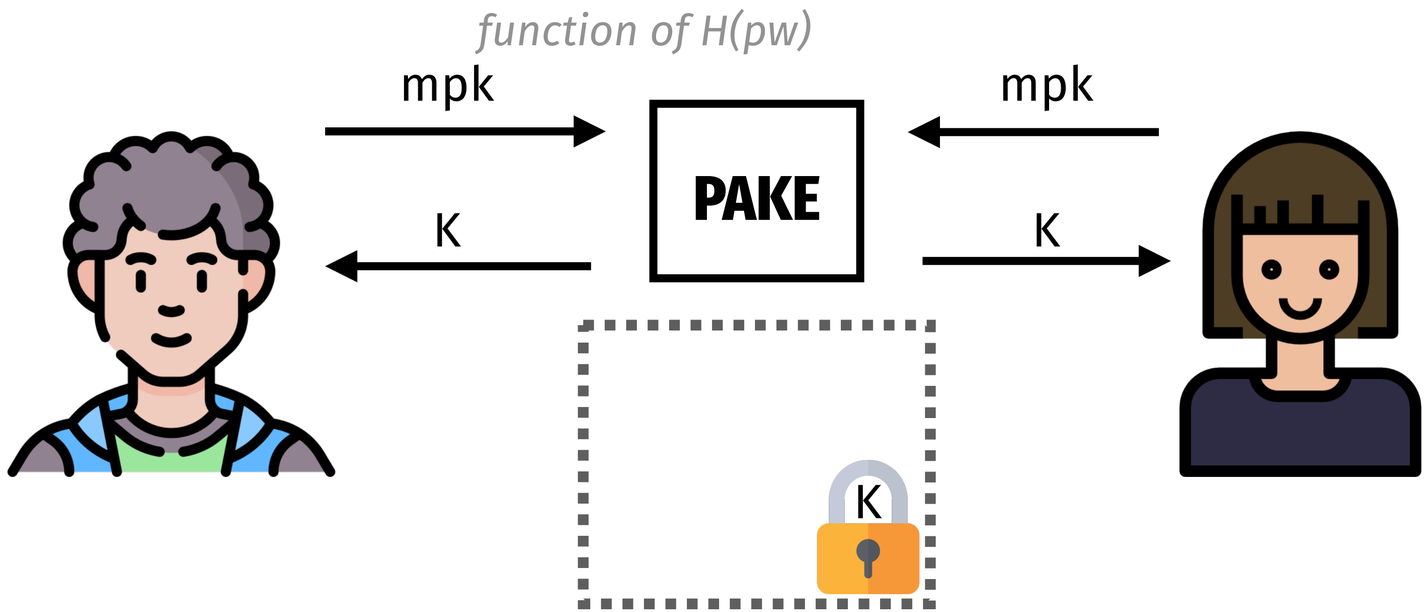

LATKE Construction

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Establish a secure channel like Ω method

Run **any IBKE in the secure channel**

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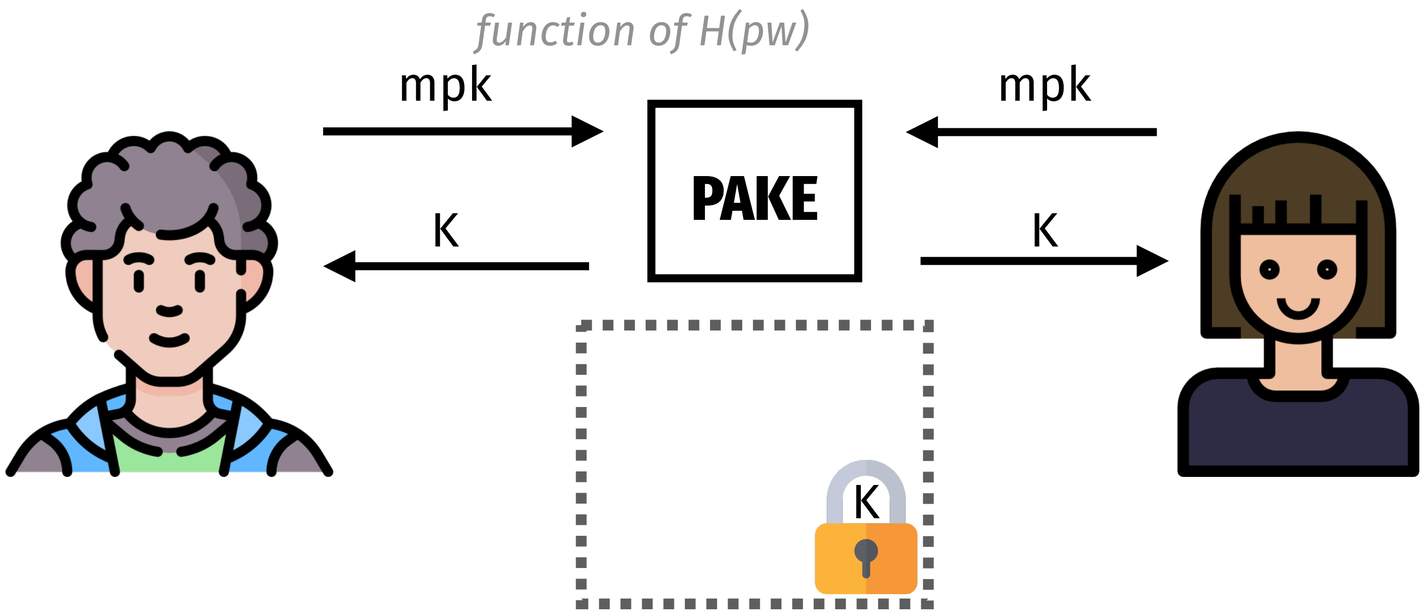

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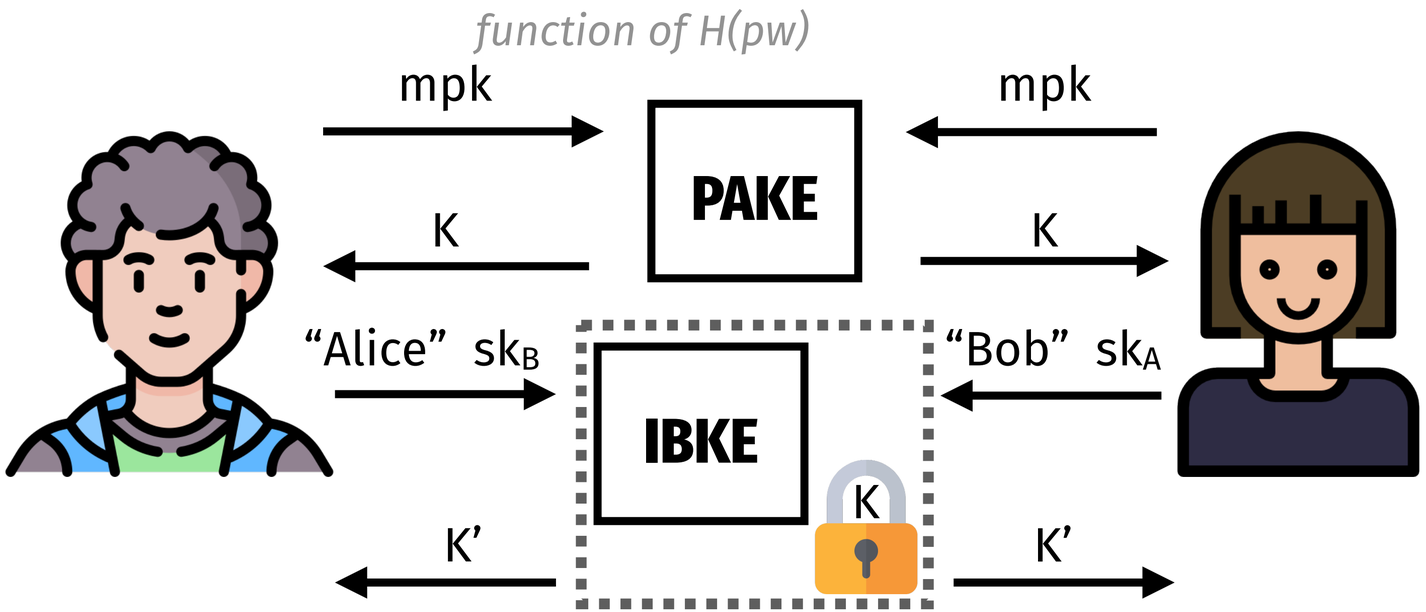

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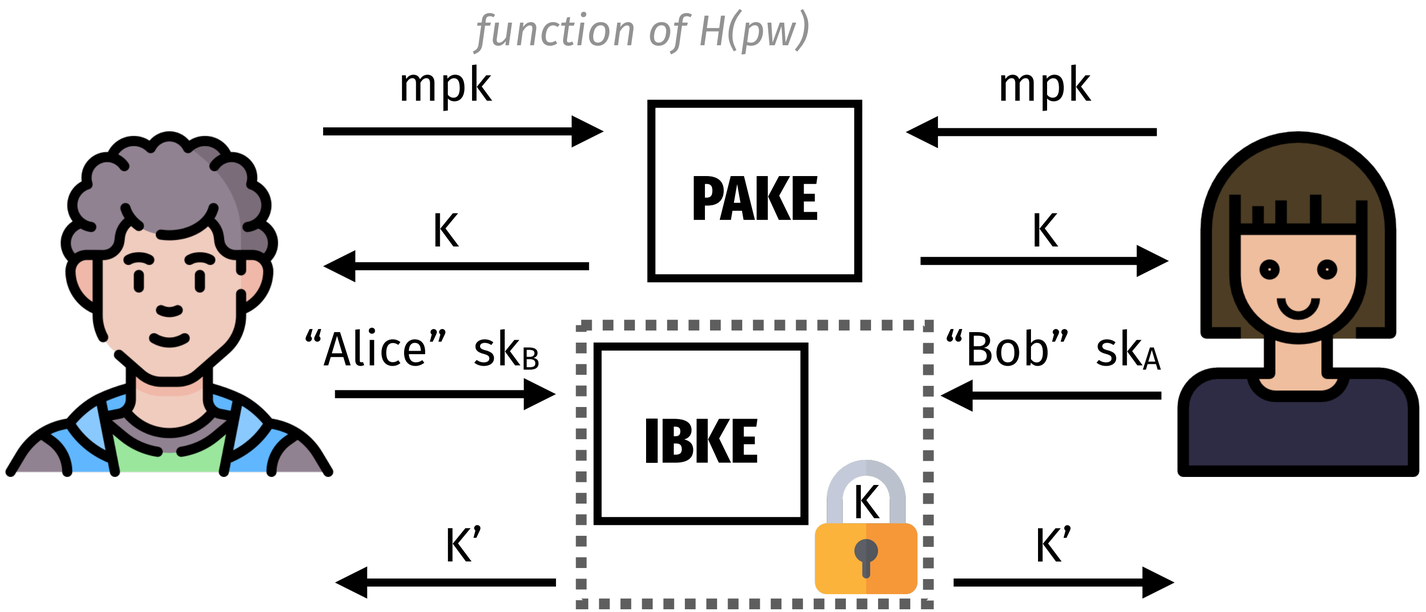

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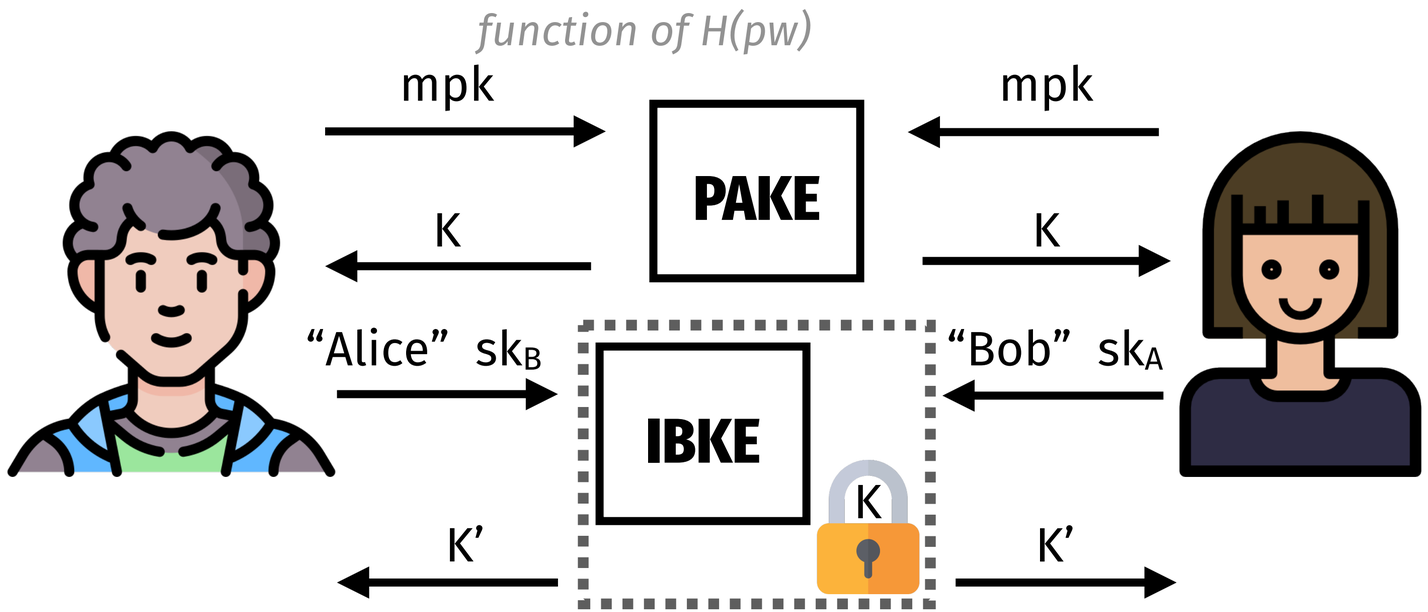

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Use **self-KGC trick** of CHIP

Establish a secure channel like Ω method

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- "Secure channel" (EUE transform)
- How to make a PQ IBKE

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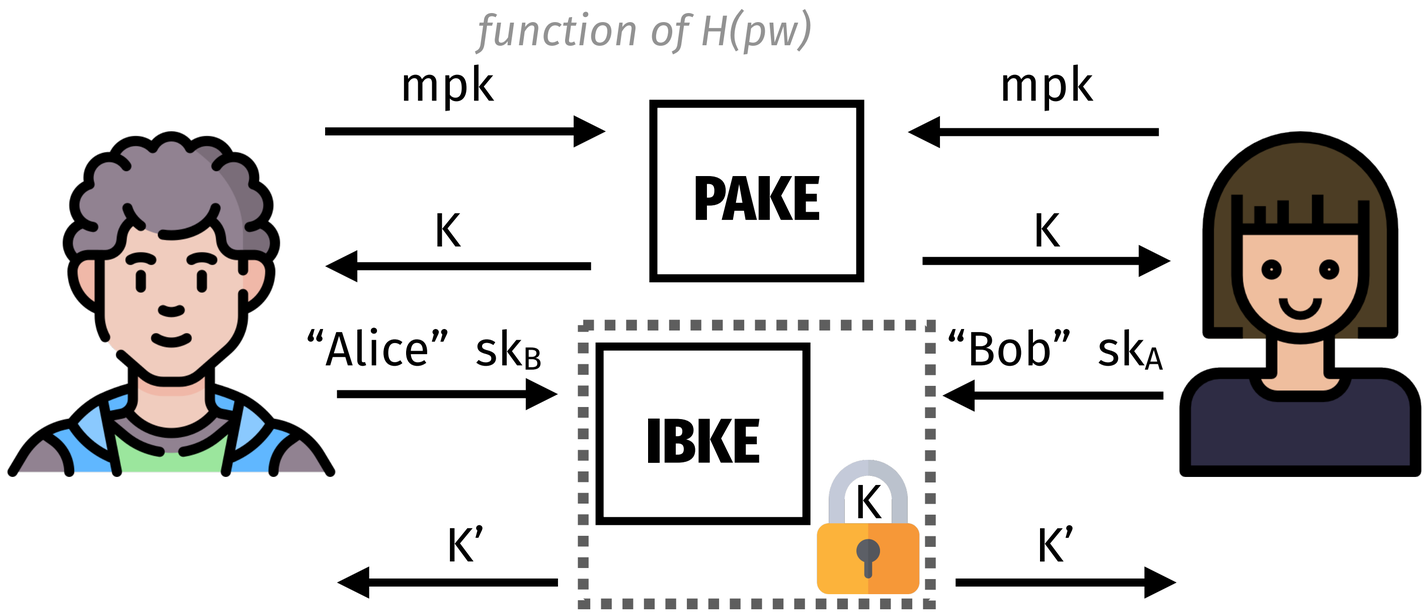

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Establish a secure channel like Ω method

Run **any IBKE in the secure channel**

Important details:

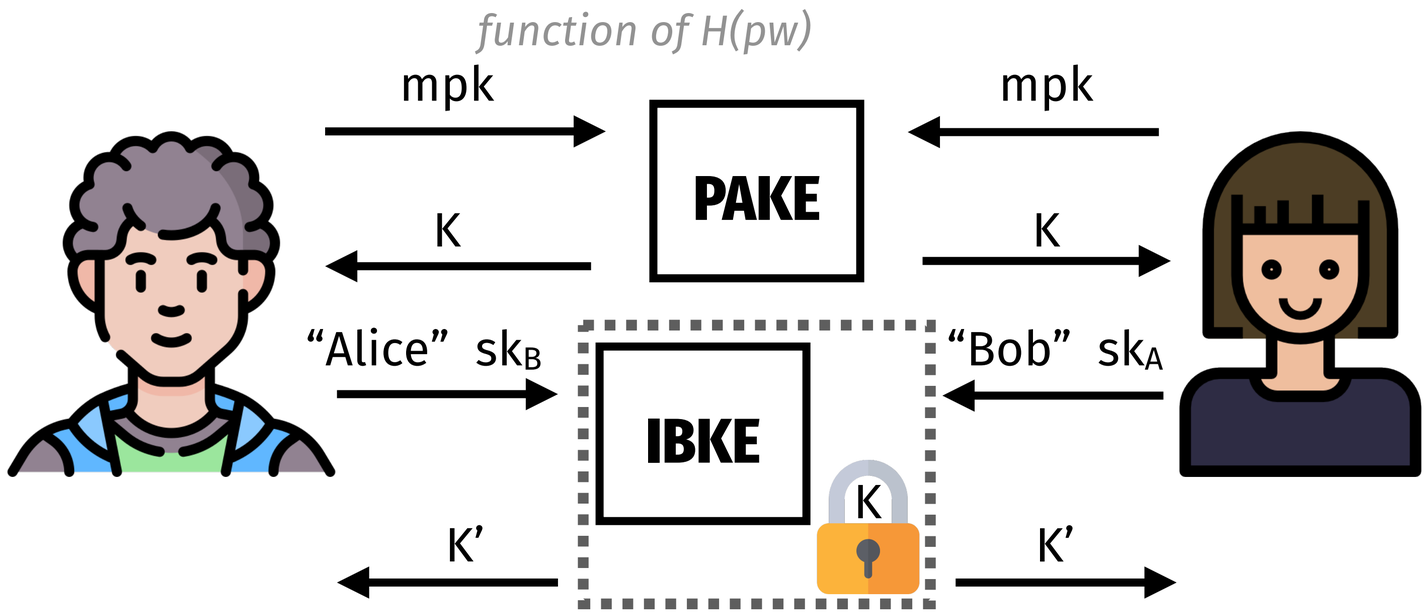
- "Secure channel" (EUE transform)
- How to make a PQ IBKE
- Security notion of IBKE (need KCIR+FS)

LATKE.Setup(pw, id) *same as CHIP*

$(msk, mpk) := KeyGen(1^\lambda; H(pw))$

$sk_{id} := Extract_{msk}(id)$

delete msk and pw



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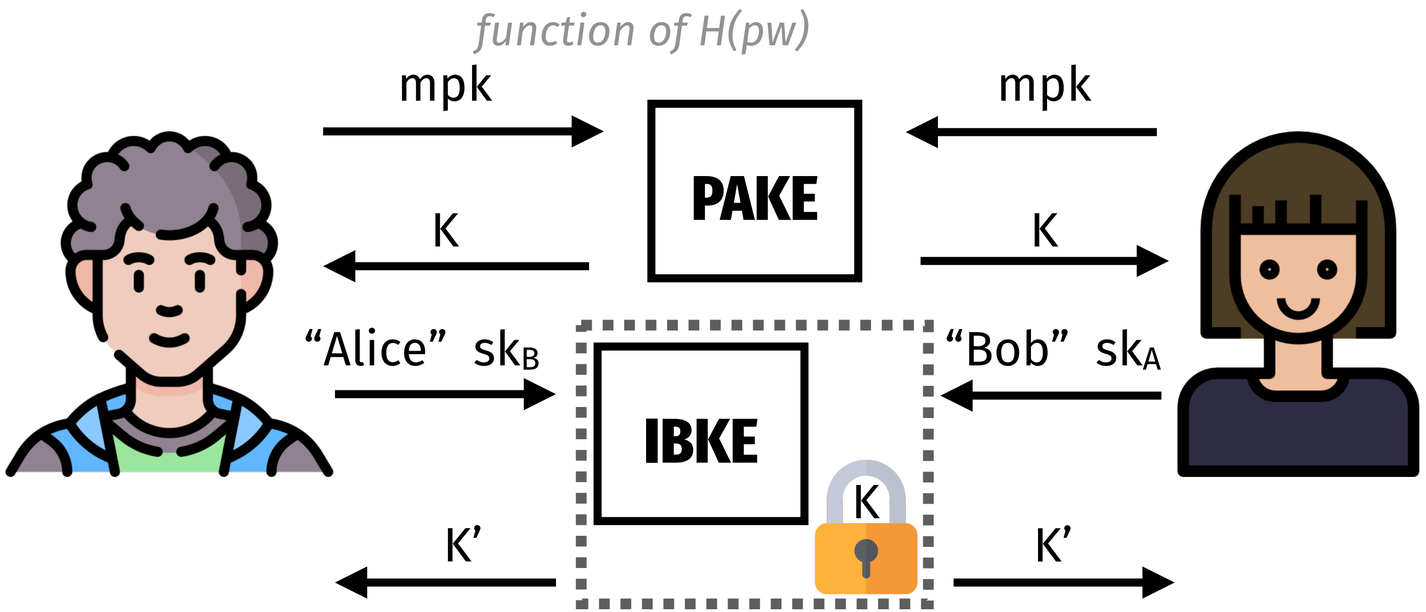

Bonus! Encrypted IBKE ⇒ identity concealment

LATKE Benchmarks

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Wrote LATKE and CHIP in Rust

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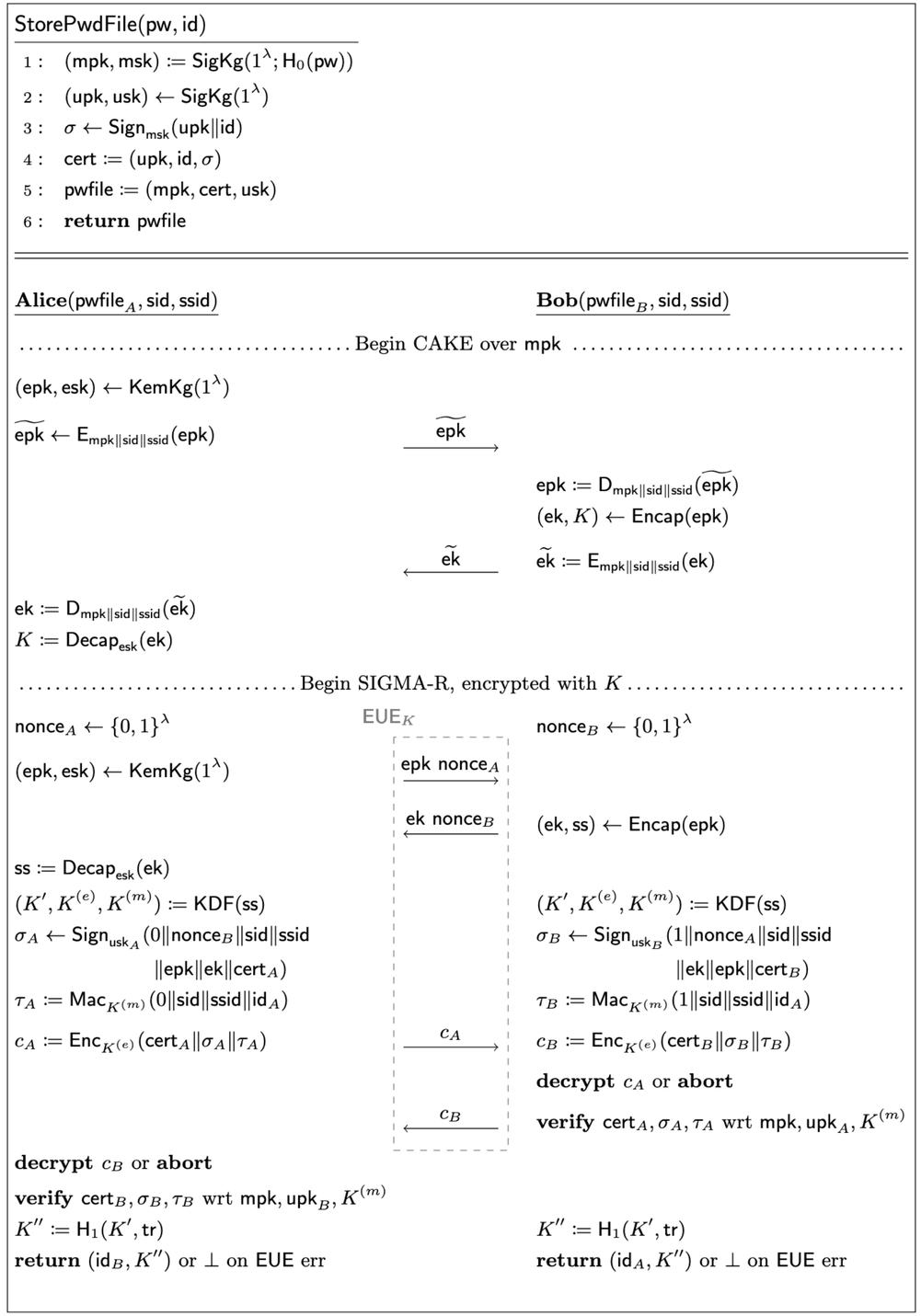

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IoT believability: ran on my old home router

$\underline{\mathsf{StorePwdFile}(\mathsf{pw}, \mathsf{id})}$

$(\mathsf{mpk}, \mathsf{msk}) := \mathsf{SigKg}(1^\lambda; \mathsf{H}_0(\mathsf{pw}))$
$(\mathsf{upk}, \mathsf{usk}) \leftarrow \mathsf{SigKg}(1^\lambda)$
$\sigma \leftarrow \mathsf{Sign}_{\mathsf{msk}}(\mathsf{upk} \| \mathsf{id})$
$\mathsf{cert} := (\mathsf{upk}, \mathsf{id}, \sigma)$
$\mathsf{pwfile} := (\mathsf{mpk}, \mathsf{cert}, \mathsf{usk})$
return pwfile

$\underline{\mathbf{Alice}(\mathsf{pwfile}_A, \mathsf{sid}, \mathsf{ssid})}$		$\underline{\mathbf{Bob}(\mathsf{pwfile}_B, \mathsf{sid}, \mathsf{ssid})}$
..... Begin CAKE over mpk		
$(\mathsf{epk}, \mathsf{esk}) \leftarrow \mathsf{KemKg}(1^\lambda)$		
$\widetilde{\mathsf{epk}} \leftarrow \mathsf{E}_{\mathsf{mpk}\|\mathsf{sid}\|\mathsf{ssid}}(\mathsf{epk})$	$\xrightarrow{\widetilde{\mathsf{epk}}}$	
		$\mathsf{epk} := \mathsf{D}_{\mathsf{mpk}\|\mathsf{sid}\|\mathsf{ssid}}(\widetilde{\mathsf{epk}})$
		$(\mathsf{ek}, K) \leftarrow \mathsf{Encap}(\mathsf{epk})$
	$\xleftarrow{\widetilde{\mathsf{ek}}}$	$\widetilde{\mathsf{ek}} := \mathsf{E}_{\mathsf{mpk}\|\mathsf{sid}\|\mathsf{ssid}}(\mathsf{ek})$
$\mathsf{ek} := \mathsf{D}_{\mathsf{mpk}\|\mathsf{sid}\|\mathsf{ssid}}(\widetilde{\mathsf{ek}})$		
$K := \mathsf{Decap}_{\mathsf{esk}}(\mathsf{ek})$		
..... Begin SIGMA-R, encrypted with K		
$\mathsf{nonce}_A \leftarrow \{0,1\}^\lambda$	EUE_K	$\mathsf{nonce}_B \leftarrow \{0,1\}^\lambda$
$(\mathsf{epk}, \mathsf{esk}) \leftarrow \mathsf{KemKg}(1^\lambda)$	$\xrightarrow{\mathsf{epk}\ \mathsf{nonce}_A}$	
	$\xleftarrow{\mathsf{ek}\ \mathsf{nonce}_B}$	$(\mathsf{ek}, \mathsf{ss}) \leftarrow \mathsf{Encap}(\mathsf{epk})$
$\mathsf{ss} := \mathsf{Decap}_{\mathsf{esk}}(\mathsf{ek})$		
$(K', K^{(e)}, K^{(m)}) := \mathsf{KDF}(\mathsf{ss})$		$(K', K^{(e)}, K^{(m)}) := \mathsf{KDF}(\mathsf{ss})$
$\sigma_A \leftarrow \mathsf{Sign}_{\mathsf{usk}_A}(0 \| \mathsf{nonce}_B \| \mathsf{sid} \| \mathsf{ssid} \| \mathsf{epk} \| \mathsf{ek} \| \mathsf{cert}_A)$		$\sigma_B \leftarrow \mathsf{Sign}_{\mathsf{usk}_B}(1 \| \mathsf{nonce}_A \| \mathsf{sid} \| \mathsf{ssid} \| \mathsf{ek} \| \mathsf{epk} \| \mathsf{cert}_B)$
$\tau_A := \mathsf{Mac}_{K^{(m)}}(0 \| \mathsf{sid} \| \mathsf{ssid} \| \mathsf{id}_A)$		$\tau_B := \mathsf{Mac}_{K^{(m)}}(1 \| \mathsf{sid} \| \mathsf{ssid} \| \mathsf{id}_A)$
$c_A := \mathsf{Enc}_{K^{(e)}}(\mathsf{cert}_A \| \sigma_A \| \tau_A)$	$\xrightarrow{c_A}$	$c_B := \mathsf{Enc}_{K^{(e)}}(\mathsf{cert}_B \| \sigma_B \| \tau_B)$
		decrypt c_A or **abort**
	$\xleftarrow{c_B}$	**verify** $\mathsf{cert}_A, \sigma_A, \tau_A$ wrt $\mathsf{mpk}, \mathsf{upk}_A, K^{(m)}$
decrypt c_B or **abort**		
verify $\mathsf{cert}_B, \sigma_B, \tau_B$ wrt $\mathsf{mpk}, \mathsf{upk}_B, K^{(m)}$		
$K'' := \mathsf{H}_1(K', \mathsf{tr})$		$K'' := \mathsf{H}_1(K', \mathsf{tr})$
return (id_B, K'') or $\perp$ on EUE err		**return** (id_A, K'') or $\perp$ on EUE err

LATKE Benchmarks

iPAKE	PQ?	Rounds	Comm.	Setup	Online	
Chip[Cpace,Fg] [CNPR22]	x	2	208B	284µs	5.33ms	(1×)
Latke[Cpace,FgC]	x	4	404B	314µs	5.56ms	(1.04×)
Latke[Cpace,IdHmqvC]	x	4	532B	467µs	5.62ms	(1.05×)
Latke[Cpace,IdSigDh]	x	2	616B	615µs	8.32ms	(1.56×)
Latke[Cake,IdΣEd25519]	enc.	6	3.53kB	813µs	5.46ms	(1.03×)
Latke[Cake,IdΣDilith2]	enc.+auth.	6	15.5kB	2.55ms	10.1ms	(1.89×)

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Tradeoff: rounds vs. speed

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Read the paper if you find this cool!

Conclusion

Constructed **LATKE** an identity-binding PAKE

Generic: takes any PAKE and (nearly) any IBKE. Hence, **PQ**

Fast: As low as 3% overhead compared to CHIP

ia.cr/2023/324
github.com/rozbb/latke-ipake
research@mrosenberg.pub

Icon credits: Flat Icons, SmashIcons, Assia Benkerroum, Freepik, Those Icons